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"A place where nobody makes fun of me because I love science" - an in-school Mini Science Museum as a meaningful learning environment to its student trustees

Ornit Spektor-Levy, Oshra Aloni, Michal Zion [a]
[a]The School of Education, Bar Ilan University, Israel

ABSTRACT

The novelty of this study is rooted in the uniqueness of its setting: Informal, in school, Mini Science Museum that is managed by high school students who also develop teaching materials and guide the visitors. The phenomenological study presented here followed, over a period of 9 months, a group of 11 students that served as the museum's trustees. It explored their perceptions of their own development, emotions and attitudes and the characteristics that turn the museum into a meaningful learning environment for its trustees. Data was gathered primarily by means of in-depth interviews and notes taken during museum staff meetings. Inductive analysis revealed three main themes: collaborative learning and guidance; interest and pleasure; self-efficacy and empowerment. In each theme, three aspects repeated with a high level of consistency: Cognitive; Emotive; and Practical. The students expressed feelings of empowerment and self-efficacy, described the museum as a learning environment that supports knowledge development in *"a fun way"*, environment that enhances collaborative learning, sense of belonging to a supportive community. Our study demonstrates that such learning environments are feasible in schools. Even though such framework may not answer the needs of all students, it may answer the needs of students who want to study more science and who are motivated to teach others.

KEYWORDS

Informal learning, science museum, collaboration, self-efficacy, community of practice

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CORRESPONDENCE Ornit Spektor-Levy ornit.spektor-levy@biu.ac.il

Introduction

The Mini Science Museum is an informal, in-school learning environment designed for the secondary school setting, which employs a constructivist approach and integrates collaborative learning strategies through scientific activities and experiments. This phenomenological study explored the impact of this learning environment on the cognitive, emotional and social development of the students who volunteer and maintain the Mini Science Museum as trustees.

The literature is replete with studies about the impact of visits in science museums on the student visitors (Bamberger, & Tal, 2007; Cox-Peterson, Marsh, Kisiel, & Melber, 2003; Falk, & Dierking, 1992; Falk & Dierking, 2004; Falk & Dierking, 2013; Jarvis, & Pell, 2005; Rennie, Evans, Mayne, & Rennie, 2010; Tal, Bamberger, & Morag, 2005). Little was published about school students who operate or take role as docents in science museums (Rix & McSorley, 1999). The novelty of this study is rooted in the uniqueness of its setting: In school Mini Science Museum that is maintained and managed by high school students who also develop teaching materials and guide the visitors' tours in the museum. Such enterprise within school and the research that follow it may shed light on the visibility of creating meaningful science learning environments within schools not only for the visitor students but also to those who maintain the science learning environment-those who are interested in science.

Science museums as a meaningful learning environment

Learning is situated. Learning is a dialogue between the individual and his or her environment through time (Falk & Dierking, 1992). Learning can be conceptualized as contextually driven effort to make meaning, to understand. It is the process and the product of the interactions between an individual's personal (Motivation and expectations; prior knowledge, interests and beliefs; choice and control), socio-cultural (within group sociocultural mediation; facilitated mediation by others) and physical (advanced organizers and orientation; design; reinforcing events and experiences outside the museum) contexts (Falk & Dierking, 2004). In museums, learning is a continuous, never-ending dialogue between the individual visitor's personal context, their physical context and their social context – the sociocultural environment (Falk & Dierking, 2013). The sociocultural environment refers to the various interactions that take place, whether with artifacts and other meditational means, or with people. The contextual model of learning is a framework designed to synthesize, reveal and organize the complexity of the experience in informal designed environments (Falk & Storksdieck, 2005). It aims at understanding the "what, where, when, why, and with whom" of learning (Falk & Dierking, 1995, p. 4). Interestingly, although originally conceived to describe learning in and from museums, the goal ultimately was to focus on the nature of the learning that people engage in, rather than necessarily where the learning happens (Tal & Dierking, 2014). These ideas, and those of others, have pushed researchers to study learners' engagement, activity, discourse, and identity work, in addition to measuring cognitive learning outcomes (Tal & Dierking, 2014). Much of this research took place in science museums.

Studies have shown that visiting a science museum has a positive effect on students' interest in and attitudes toward science (Jarvis & Pell 2005; Schwan, Grajal, & Lewalter, 2014) and on students' achievements in science and mathematics (Suter, 2014; Tenenbaum, Rappolt-Schlichtmann, & Vogel Zanger, 2004). A similar positive effect was found by Rix and McSorley (1999) among students who interacted with exhibits and with each other while visiting in a mini-science-museum located in their school and operated by their fellow students. Studies show that in order to achieve situated and meaningful learning, the visit in the museum should be based on active hands-on experience rather on lectures (Cox-Peterson et al. 2003; Tal, Bamberger, & Morag, 2005; Tran, 2007). In this context, the science museum can be seen as an informal learning environment (Rennie, 2007; Schwan, Grajal, & Lewalter, 2014; Shaby, Assaraf, & Tishler, 2016; Yoon, et al., 2013). Informal learning usually takes place outside the classroom. It is defined in various ways and contexts (e.g. Bamberger & Tal 2007; Bitgood, Serrell, & Thompson, 1994; Hofstein & Rosenfeld, 1996; Rennie, Feher, Dierking, & Falk, 2003; Wellington, 1990), but the following key characteristics can be extrapolated: Involvement in this type of learning is voluntary; The structure of the learning program is open, offering students options in lieu of didactic teaching methods; The activities are not evaluated or graded; Social interaction takes place in heterogeneous groups, which can also include participants of various ages.

Although the study described here took place in Mini Science Museum within school, the nature of its operation is informal: The students who operate the museum (trustees) are volunteers; The structure of the learning program is flexible and determined by the trustees; The guidance and learning activities in the museum employ variety of instructional didactics and active learning experiences; Social interactions take place between trustees, between trustees and visitors and between visitors while operating the exhibits. Thus the Mini Science Museum is informal in its nature.

Science museums as environments that enhance self-efficacy

One way of constructing meaningful learning and understanding is fostering a sense of self-efficacy. Self-efficacy is defined by Bandura (1977) as the strength of a person's conviction that he or she can successfully execute a behavior required to produce a certain outcome. Bandura contends that self-efficacy is not a global trait, but is a situation-specific factor that is execute only when proper incentives and the necessary skills are present. According to Britner (2002), a sense of self-efficacy affects people's behavior, their choice of tasks, the degree of effort and persistence they will invest in a task, and the flexibility of their thinking. Thus, the extent of individuals' self-efficacy helps to predict success more than their current performance (Bandura 1997; Jansen, Scherer, & Schroeders, 2015; Pintrich & Schunk 2002). Literature on self-efficacy (e.g. Pajares & Urdan 2006; Schunk & Meece 2006; Schunk & Pajares 2001; Tsai, Ho, Liang, & Lin, 2011) has noted a variety of factors that are liable to affect it. Bandura (1977) hypothesized that information about one's efficacy expectations can be modified through four major sources of information: mastery experiences, physiological states, verbal persuasion, and vicarious experiences like modeling. Observing peers successfully carrying out a task may increase the observers' sense of self-efficacy and motivate them to carry out the task (Bandura, 1986; Schunk, 1987). The effectiveness of modeling on one's efficacy perceptions and performance depends on several modeling variables, e.g. model status, model competence (McCullagh, 1986), similarities to the model in terms of performance or personal characteristics (McCullagh, 1986; Marx & Ko, 2012). Lirgg and Feltz (1991) found that subjects viewing either a skilled teacher or skilled peer performed better and had higher efficacy beliefs than subjects who viewed an unskilled teacher or an unskilled peer. Such modeling may occur in science museums where the docents (and the visitors) are high school students as happened to be in our study. Furthermore, Hymel, Comfort, Schonert-Reichl, and McDougall (1996) argue that feelings of self-efficacy, as well as students' academic achievements, are affected by the degree of students' involvement in school. However, findings show that the sense of self-efficacy decreases over the years of learning at school (Pintrich & Schunk 2002). Integration of informal settings can moderate this inclination.

Informal settings may support the construction of communities of practice–Students in a social network tend to be similar to each other (Schunk & Meece 2006), which increases the possibility of influence through a model similarity (Ryan, 2000). Students and teachers need to understand that science and science education are always a part of larger communities (Lemke, 2001) and their cultures, i.e. communities of practice. One way to increase students' sense of self-efficacy in science learning is to integrate them into communities of practice such as science museums (Rahm, 2004; Velure-Roholt & Steiner 2005).

School students can integrate into science museum's activities in diverse roles like developing exhibits, planning learning events around the exhibits etc. (Rahm, 2004). One such program is YA– Youth ALIVE: Youth Achievement through Learning, Involvement, Volunteering, and Employment. The program, developed by the Science Museum of Minnesota, was designed to involve youth in the course of real, significant, and authentic work in the museum. This program employed teens aged 14-17 at the museum, where for all intents and purposes they formed part of its team (Velure-Roholt & Steiner, 2005). Velure-Roholt and Steiner (2005) claimed that in order for the youth to feel that they are contributing and respected, it is important to let everyone choose their own task and area of interest, and to create the time and place for them to collaborate, exchange ideas, and plan. Another way of integrating science with significant, real, and authentic work is the establishment of a science museum within the walls of the school, as was done in the case addressed in this study. Similar examples of in-school science museum are rare. Most examples in literature refer to in-school art museums or other topics like history or geography in primary schools. D'Acquisto (2006) emphasizes that school museum projects are catalysts for student learning. These motivating classroom projects encourage students to learn new knowledge and use that knowledge creatively. Students explore academic content through an intellectually demanding task, which makes learning more relevant and provides an opportunity to develop valuable collaboration, communication, problem-solving, and creative thinking skills. D'Acquisto (2010) describes examples of in-school child-led museums. Ryder and Annis (2016) also describe an in-school child-curated museum that provides pupils with opportunities to share artefacts and showcase learning with the school and wider community. The aim is for the museum to be an interactive area which enables children to build on their enquiry skills and develop a sense of curiosity. Topics on display in the museum include science, history and geography. The curators have to apply for their position. Curators are responsible for collecting pieces of work and artefacts, thus making the museum a child-led project.

The in-School Mini Science Museum

The initiative was based on two central assumptions. First, that developing an interactive learning environment facilitates experiential learning and motivates students to ask questions and deepen their knowledge. Second, that for many students a diverse learning environment opens up alternative ways to learn and to make use of their personal skills, which also helps to improve attitudes toward the sciences among Junior High School (JHS) and high school students.

The Mini Science Museum is a unique learning environment located in a six-year secondary school (7^{th}-12^{th} grade) in a central city. The museum features exhibits that display scientific principles and phenomena concerning the subjects like: light, sound, electricity, phosphorus materials and center of gravity. It is an interactive learning environment that facilitates experiential learning and motivates students to try and touch the exhibits, to collaborate and to ask questions.

One example of experiential learning takes place near the phosphorescence exhibit. A big board coated with phosphorous material is located in a dark chamber. Every 20 seconds light flashes. Visitors stand against the board in different (funny) positions and after the flash of light they can see their silhouette on the board. They can explore the effect of different light colors (wave length) on the creation of the silhouettes. In another exhibit a video camera that absorb Infra-red (IF) beams is connected to TV screen. The visitors enter a dark room and see themselves on the screen. They have to detect where the camera is located. Then they can use the camera in order to find out what objects are located inside a dark sealed box. They discuss in groups the scientific principle and the technological apparatus that activated the IR camera and the possible uses of IR camera.

It is a quality exposure to science due to its interactivity (games), its relevance (e.g. how loudspeakers work) and its simplicity (hands-on and illustrated demonstrations). The museum provides science enrichment activities for the JHS students (ages 12-15) in school, nearby elementary school students, private events like "Scientific Birthday Parties," etc. The staff members are students from the school in which the museum is located. These students are known as 'trustees' because they hold a position of trust and responsibility. The student trustees work as volunteers, mainly during after-school hours. All trustees take part in maintaining the exhibitions, and in developing instructional materials and learning activities. Only some of the trustees feel confident enough to also take on the role of guide and lead visitors on tours through the museum. For each group visit, the museum's trustees decide upon a central theme. They hold a staff meeting to divide responsibilities refresh procedures and discuss scientific content. The tour generally begins with a preliminary explanation about the scientific topic. Then the group divides into smaller groups, each accompanied by one or more guides. These groups engage in hands-on activities at various stations near exhibitions that encourage exploration, group discussions and articulation of the phenomena. The tour ends with a concluding discussion and visitors' reflections.

The Mini Science Museum as a community of practice

The Mini Science Museum has become–what Lave and Wenger (1991) have described as a community of practice. Within a community of practice, group members share interest and develop practices together, learn from their interactions with one another, and gain opportunities to develop personally, professionally, and/or intellectually (Wenger, 1998). The individual learner in the community both defines and is defined by these relationships (Mills, 2011). Thus, learning becomes embedded within a social context.

In communities of practice, the social context is usually realized through collaborative learning. The trustees in the Mini Science Museum exchange knowledge, share ideas and reflect upon their mutual activities. These components constitute collaborative learning. The effectiveness of collaborative learning has been demonstrated in reviews and meta-analyses (Hattie, 2009; Johnson & Johnson, 2009; Slavin, Hurley, & Chamberlain, 2003).

When individuals learn collaboratively in small groups, the active exchange of ideas increases interest and engagement (Barron, 2003), enhance conceptual knowledge and understanding (Van Boxtel, van der Linden, & Kanselaar, 2000), promotes critical thinking (Gokhale, 1995), long retention of information and high levels of thought (Johnson & Johnson 1986), social sharing of co-regulation (Salonen, Vauras & Efklides, 2005; Vauras, Salonen, & Kinnunen, 2009). The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus social and individual processes occur concurrently (Volet, Vauras, & Salonen, 2009). Research on collaborative learning strongly emphasizes theoretical and empirical support for the cognitive and motivational benefits of collaborative, as opposed to individualistic learning activities (Webb, Nemer, & Ing, 2006). Thus, collaborative learning generates cognitive partnerships (e.g., King, 2002). Achieving such coordination is not an easy process, as each group member is a self-regulating agent with unique cognitions and emotions, which can create major challenges to motivation in social interactive contexts (Järvelä, Volet, & Järvenoja, 2010).

In order to gain a thorough understanding of the individual and social processes that the Mini Science Museum trustees went through, in order to find out whether cognitive partnership was achieved, what personal gains the trustees earn; in order to verify whether such scientific community of practice is visible in school environment, we decided to apply a qualitative approach and to delve into the texts the participants said in interviews and during staff bMuseum’s trustees. It explored their perceptions of their own development, emotions and attitudes and of their impact on the museum’s visitors.

Objectives and research questions

The objective of this qualitative study was to assess the effectivity of the Mini Science Museum as a meaningful learning environment for its trustees. The study documented and analyzed 11 student trustees' responses in order to address the following questions:

1. What are the perceived personal gains and most important aspects of the Mini Science Museum from the viewpoint of its trustees?

2. What characteristics turn the in school Mini Science Museum into a meaningful learning environment for its trustees?

Research methods

Participants

The study took place at an urban high school, the population of which is a heterogeneous mix in terms of socioeconomic status. Eleven participants (6 boys, 5 girls) agreed to take part in this research (Table 1). All of them were trustees of the Mini Science Museum. At the time of the study, two had just graduated, four were in high school (grades 10-12), and five in junior high (grades 8-9).

Table 1

Composition of sample: Gender, age-grade when joined the museum and when study started, tenure when study started and role (N=11)

Name	Gender	Age-grade when joined the mini-museum	Age-grade when study started (*Just graduated)	Tenure as trustee when study started (in months)	Role at the museum: Development & Guidance
Amy	Girl	8	8	6	+
May	Girl	8	9	24	+
Talia	Girl	10	11	24	+
Joy	Girl	10	12*	36	+
Noga	Girl	8	8	6	+
Robbie	Boy	8	10	36	+
Idan	Boy	8	8	6	+
Udi	Boy	9	11	36	+
Ronnie	Boy	8	8	6	+
Eran	Boy	8	12*	60	+
Tom	Boy	9	10	12	+

Data Collection

As mentioned before, the study employed a phenomenological approach. Data was gathered primarily by means of in-depth interviews and notes taken during museum staff meetings.

Staff Meetings

In order to prepare the guided tours in the museum, or to discuss the museum maintenance, staff meetings were held by the museum's student trustees. The frequency of the meetings varied depending on how many school activities or visits to the museum needed to be planned. During the nine months of this research, the museum held fifteen guided group visits (all from different schools). Part of the meetings was always devoted to reflective, facilitated discussions after activities. Each of the guides shared their experience with the group they had shown around, including successful strategies to be repeated and challenges they wished to discuss and better address in the future. One of the authors facilitated these meetings as an active participant and observer, attempting to ensure that all guides were given an opportunity to speak and listen.

Interviews

We held in-depth, semi-structured interviews with 11 trustees, which addressed their perceptions regarding the cognitive, emotional and practical contributions of the work in the Mini Science Museum to themselves. We asked questions like: Why did you join the museum? What did you know about the museum before you joined it? What knowledge and skills are needed to become a trustee in the Mini Science Museum? How do you divide responsibilities and duties? What is your role in the museum and which role do you prefer? What is the importance, if any, of the museum, for you, for the school, for others?

The interviews lasted 25–40 minutes. Six interviews were held at school during school hours, and five were held in students' homes.

Data Analysis

Analysis of the data was based on the Grounded Theory approach (Glaser & Strauss, 1967) which seeks to construct a theory through qualitative analysis of data. The aim is not to discover the theory, but a theory that aids understanding and action in the area under investigation (Heath & Cowley, 2004, p. 149). Glaser (1998) further contend that this is a process whereby as the theory begins to emerge, literature of close relevance is recognized or read and its powerful impact bends the emerging theory from its true path (Heath & Cowley, 2004, p. 143). This cognitive process develops from the data, through ideas and insights, deduction and verification, to empirical generalization and on to theory. Ideas and categories are constantly refitted (Glaser, 1978) and verified in order to avoid forcing data (Heath & Cowley, 2004). Following this approach, all data gathered in this study was recorded, transcribed verbatim, and analyzed in three stages. First the researchers read the text several times, scrutinizing data sets individually to search for categories through thematic data analysis and using episodes as analysis units (Shkedi, 2005).

The emerging themes were reexamined and reorganized into three main themes. In second stage, the main themes were further analyzed into sub-themes. Those sub-themes were examined and similar sub-themes were grouped as significant aspects. The third stage of the inductive data analysis generated a concise master outline that offered a holistic description of the trustees' quotations and perceptions according to all themes and aspects. The three stages of analysis were validated by two independent science education researchers with experience in qualitative research, and academic knowledge in learning environments that support scientific literacy. In case of disagreement between experts, discussions took place until full agreement was achieved.

Results

The data collection through notes taken in staff meetings and the trustees' responses to the in-depth interviews resulted in substantial amount of textual data. In this paper we aim to assess the effectivity of the Mini Science Museum as a meaningful learning environment for its trustees. Therefore we thoroughly analyzed the data, of 171 quotations relevant to this study, in order to first find out what are the perceived personal gains and most important aspects of the Mini Science Museum from the viewpoint of its trustees.

Data analysis revealed three main themes. The first, ***collaborative learning and guidance***, refers to students' responses towards and perceptions of the teamwork they engaged in while preparing activities, acquiring and transferring scientific knowledge, and acquiring guidance skills. The second, ***interest and pleasure***, refers to students' responses that highlight the uniqueness of the learning environment in the museum as one that creates interest and pleasure in learning–for the trustees themselves and for the visitors (from their own viewpoint). The third aspect, ***self-efficacy and empowerment***, refers to students' responses that address changes in their own sense of self-efficacy and empowerment in the context of their work in the Mini Science Museum. After identifying the three main themes that emerged for data, we performed further inductive analysis. This stage divulged three aspects that repeated with a high level of consistency in each main theme: **Cognitive aspect** - quotes describing gaining of knowledge and scientific understanding; **Emotive aspect** - quotes describing feelings and attitudes; **Practical aspect** - quotes describing the acquisition and implementation of guidance skills. Table 2 presents the frequencies of the quotations related to the main themes and aspects.

Table 2

Frequency of quotations by main themes and aspects (n=11)

Main themes	Aspects			Sum
	Cognitive aspect - Knowledge	Emotive aspect – Feelings & Attitudes	Practical aspect – Guidance Skills	
Collaborative Learning and Guidance	11	22	17	50
Interest & Pleasure	27	30	13	70
Self-efficacy & Empowerment	14	14	23	51
Sum	52	66	53	171

The frequencies of quotations in table 2 do not indicate the number of speakers, since one interviewee may refer to a certain aspect more than once and may not refer at all to a certain aspect. The qualitative analysis and exemplified quotations of the three themes, and three aspects are presented in table 3.

Table 3 Exemplified quotations relating to the three main themes and three aspects (n = 11, interviewee ID in parentheses).

Themes	Aspects		
	Cognitive	**Emotive**	**Practical**
Collaborative Learning and Guidance	*"At the beginning they* [the more experienced] *explain to you how to explain to kids, exactly what to do, how to prepare before guiding, how to work before guiding and after guiding. As you grow and guide more and more, you become a better guide"* (May) *"There were the founders and they were smarter. We would come to them with problems and what they said always carried more weight. They knew more and knew the museum better."* (Joy)	*"Even if you get stuck* [during a tour] *somewhere, they* [the more experienced] *can take over and you don't need to freak out if you don't remember or something…you just feel safe."* (Amy) *"The mini-museum is a family, not just someplace I volunteer where I have friends; it's a real family."* (May) *"When we meet to do the summary there's always lots of fun and laughter."* (May) *"Socially, it is about connecting. Even with older kids that aren't as close to me in age."*(Idan)	*"I'm going to be a mathematics tutor and teach in a youth enrichment program, and all because of skills I learned here."* (Eran) *"As a team, we have to work together in front of people, and if we're not close, there won't really be any teamwork between us".* (Ronnie) *"You help your friends and your friends help you."* (Talia) *"The ability to work in a group, to be part of a team and not just be contrary all the time; to be part of something; to belong to something."* (Joy)
Interest & Enjoinment	*"I walked in the mini-museum, looked around and said, great, all sorts of machines you can press on and they do things. And then they*	*"It's a place where no one laughs at me because I like science, because I'm*	*"Primarily, I joined the Mini-Museum for the simple reason that I really love guiding."* (Idan)

CORRESPONDENCE Ornit Spektor-Levy ✉ ornit.spektor-levy@biu.ac.il

	explained the [scientific] *principles…at school they don't say anything interesting, or nothing I didn't already know. And I thought this* [the museum] *would definitely be more interesting."* (Joy) *"You can do lots of other volunteering stuff at school…but this is the only project in school that really gives students some learning, some knowledge that can be implemented in class."* (Ronnie) *"Biology, physics, chemistry are some of the most interesting things in the world…but they're so wronged the way they're taught in school, and here we get it in a different way, at least the physics."* (Joy) *They* [the trustees] *are interested in being involved in the community in contributing, they're interested in learning not only during school hours."*(Tom)	*interested, because I get good grades."* (May). *"Sometimes it was just clearing my head when I was messed up. You could come, open the door and sit down and deal with something that isn't you, isn't your life"* (Joy) *"The students who volunteer here really want to be here."* (Udi) *"Not only do they* [the visitors] *enjoy the guided sessions, they also go to the workshop, and also create something nice for themselves."* (Eran)	*"Science seems like a repellent subject, meant just for the chosen few who understand it. We try to present science in a different light that's easy to understand. Through simple things like games, people discover that physics and chemistry are not the end of the world and they easy to understand."* (Udi) *"I think it* [our guidance] *helps because science can be viewed as grey and uninteresting. In the Mini-Museum they really enjoy themselves"* (Tom)
Self-efficacy & Empowerment	*"I learned a lot. It also helped me understand other things and after that I stayed in physics. I taught in the museum things that I learned again later in my studies."* (Joy)	*"I think it made me take on more responsibility, where sometimes I didn't know if I would make it but now I know that if I say I will, then I will…it gave me the ability to believe in myself that I can."*(Amy).	*"I understand how to work with different types of people, when I give them the lecture, how to convey it in my tone of voice, with my hands."* (Ronnie)

	“Half the time we’re throwing around ideas and that gives you lots of creative freedom and inspiration.” (Eran) *"I learnt a lot in the museum. I acquired knowledge I had not encountered before, like the thing with how to generate electricity".* (Ronnie) *"first of all it gave me more knowledge, lots more. I now know things that I didn't even think would interest me."* (Amy)	*"I feel I’m contributing, I’m helping, that in fact I contribute to the community and help kids learn in a fun way.”* (Idan) *“It's a very small environment to learn in – very flexible.”* (Joy) *“I remember it looked really impressive being a guide, even guiding children not much younger than you.”* (Idan) *“I feel this is the place for me, and I want to be active and successful.”* (Noga)	*“Trustees in the Mini Museum acquire qualifications like guidance skills, functioning under stress, learning skills, recognizing when you need to know more. These qualifications are important throughout life."* (Udi) *"I learned a lot of new things about myself... how to react under pressure, in a situation where I do not know what to say, when I get stuck how to smooth things out, how to deal with kids…I developed my abilities and I’m always happy to do these things, to improve.”* (Robbie)

In the following sections we will elaborate on each of the three main themes and the subsequent aspects.

Collaborative Learning and guidance

Total of 50 quotes were categorized as indications of *collaborative learning and guidance* (Table 2). Table 3 shows exemplify quotations regarding the *Collaborative Learning and Guidance* theme, according to the three aspects: cognitive, emotive, and practical.

Eleven quotes describe the cognitive benefits of being trustee of the Mini Science Museum and working in collaboration with other trustees (table 2, 3). It is interesting to note that participants almost did not mention how they themselves contributed to the scientific knowledge of other. They mainly mentioned progress in their own knowledge thanks to experienced peers and group discussions. The trustees described collaborative assistance in learning the scientific content. The elder trustees and the senior ones are almost admired by the younger ones. The most prominent finding is the frequency of 22 quotes in the emotive aspect in comparison to the cognitive aspect (11 quotes) and the practical aspect (17 quotes). The mini Science Museum trustees expressed feelings of confidence and support from behalf of their peers during the different activities. Their emotions are reflected in their descriptions of the enjoyment from the collaborative learning and the contribution to visitors. This may due to factors such as the non-formal atmosphere, small group, like Talia explained: *“because it’s not mandatory and because it’s small, the people who come really want to be here and they fit in better,”* and Udi noted that *“it’s like a scientific home.”*

Some participants describe the staff meetings as fun with lots of laughter. May said, *“The friendship always cheers me up…when we meet to do the summary there’s always lots of fun and laughter.”*

In the practical aspect they describe the acquisition of guidance skills and improvement of these skills along the volunteering period in the museum. Trustees explain their satisfaction from the way they gained better guidance skills due to the scaffolding nature of the training *“They assign less senior guides and more novice ones so they can gain experience and the seniors should be there to be supportive.”* (Tom)

To summarize, the participants' remarks about collaborative learning and guidance emphasize the importance of the social aspect. The trustees explained how new guides were trained for the role by the elder, more experienced guides, and would run their first visitors' guiding as co-guidance with the more experienced mentor who support the novice one. Such training required the trainees to be able to convey a small, specific number of concepts and principles to their audience as part of the tour, but their student mentors used the staff meetings to help the new guides acquire knowledge on a wider scale, beyond what was strictly necessary for the tours. This mentoring, supportive atmosphere made them feel safe and fun.

CORRESPONDENCE Ornit Spektor-Levy ornit.spektor-levy@biu.ac.il

Interest and Enjoyment

Table 2 and table 3 show the distribution and examples of quotations relating to the Mini Museum learning environment that creates interest and enjoyment in learning. This theme holds the highest incidences of quotations (70 quotes). In this theme as well, the emotive aspect is prominent (30 quotes) in comparison to the cognitive (27 quotes) and the practical (13 quotes) aspect.

During the content analysis we noted that all the participants used positive phrases like: *"it was fun," "I enjoyed," "I love to," "it helped,"* all of which illustrate the pleasure and satisfaction the trustees felt during their experience working in the museum.

The participants' remarks reveal their satisfaction in gaining scientific knowledge and the feeling that they reached a learning environment that supports their eagerness to know more and provide ways to transfer the knowledge to others: *"They* [the trustees] *are interested in being involved in the community, in contributing. They are interested in learning not only during school hours" (Tom)*. One of the interviewees better expressed his emotion: *"It's a place where no one laughs at me because I like science, because I'm interested, because I get good grades." (May).*

All participants expressed their appreciation to the Mini Science Museum as an in-school unique learning environment that supports knowledge development in *"a fun way" (Idan).* Most of them emphasize that the school management provides many opportunities for students to take action and contribute to the community in school and out of school. However, most other activities are focused mainly on moral issues or aiding special needs communities. Only the Mini Museum provides opportunities to develop scientific knowledge and thus may support trustees' achievements in class or other studying frameworks: *"It makes a place for science, it's not just another volunteer activity at school, it's something else. You also learn science from it" (May)*.

Most of them emphasized their contribution to the knowledge of school students and visitors and to their attitudes toward science: *"I think it helps because science can be viewed as boring and not interesting. In the Mini-Museum they* [the visitors] *really enjoy" (Tom)*. Amy said: *"I really enjoy guiding all the groups and I enjoy it when they participate and show interest and then it is fun for everyone."*

Sixteen times participants described how visitors like the visit and activities in the Mini Science Museum. They mention a lot the word "fun" and how a visit in the museum can improve the visitors' attitudes toward science in general and science learning in particular.

As part of the practical point of view, participants were enthusiastic (10 quotes) about the positive effect of hands-on activities and play-based activities they conducted, on the visitors' attitudes and enjoyment to learn science: *"In simple things like a game, people, students, discover that sciences aren't so terrible and they connect more with sciences ... we provide more than the just a matter of learning." (Udi)*

It is important to note one voice of Ronnie that expressed the fact that the Mini Science Museum was a place even for those who might not be so interested in science but still felt safe and growth: *"...and if you're not that interested in science, that's fine, you* *can come here, give the tours and pick up other things that could maybe help you down the line."*

Self-Efficacy and Empowerment

Fifty one quotes were categorized as providing evidences of sense of self-efficacy and feelings of empowerment.

Table 2 and table 3 show the distribution and examples of quotations in this theme: *Self-Efficacy* and *Empowerment*, according to the three aspects.

In the students' own words, clear references were found to indicate empowerment and personal development in the cognitive dimension (14 quotes): *"I learnt a lot in the Mini Science Museum. I acquired knowledge I did not encounter before. For example, the thing with how to generate electricity. In the museum we learnt about different ways to produce electricity, which most of them I did not heard of before and did not know how it works" (Ronnie).* Relating to knowledge acquisition participants indicated the fact that when students visit the museum they learn beyond the scientific topics they learn in school science lessons. As one of the trustees said: *"They* [the visitors] *learn more than what they learn in class and not from text books. They see with their own eyes and it helps to understand. They gain more knowledge" (Idan).*

Relating to the emotive aspect, participants testified that they feel good and productive (14 quotes) during their volunteering in the museum: *"I feel I'm contributing, I'm helping, that in fact I contribute to the community and help kids learn in a fun way" (Idan).* Relating to the emotive aspect, participants indicated the fact that the mini museum provides the trustees opportunities to express themselves and execute their abilities. Eran said: *"Being here gave me a huge sense of purpose. I saw tons of people coming here and they haven't got a clue about the principles of physics and how things work, and they see lots of things as magic and as something that shouldn't be investigated because it's beyond them. And it's important to me to dispel that illusion."*

The students express feelings of empowerment and a sense of self-efficacy, primarily in the practical dimension of guiding skills (23 quotes), as a result of the guidance experience: *"The guided sessions taught me to speak, to construct the things I want to say… The ability to face an audience, to captivate a class… It was so helpful to my life to my self-confidence" (Joy)*. On practical level, one of the interviewees summed the practical aspect of the growth in self efficacy: *"I learned a lot of new things about myself... how to react under pressure, in a situation that I do not know what to say, when I get stuck how to smooth things out, to deal with kids… I developed my abilities and I'm always happy to do these things, to improve" (Robbie)*.

One of the interviewees elaborated about the empowerment and skills all the mini museum guides can gain: *"As for the students who guide the tours in the mini museum, it is of great importance, since they acquire qualifications, like guidance skills, functioning under stress, learning skills, recognizing when you need to know more. These qualifications are important throughout life…" (Udi)*

The Mini Science Museum as a meaningful learning environment

The qualitative inductive analysis of data and its quantitative representation in table 2 emphasize the important outcomes of being a trustee in the Mini Science Museum and that is that the trustees experience and understand the gains of their acts. Table 2 shows that out of the 171 quotes that construct the data base of this study, most quotes are related to emotive aspect. From the three themes found, the ***Interest & Enjoinment*** is prominent with 70 quotes. Out of the three aspects found, the emotive one was most prominent – 66 quotes. This outcome may be summarized by Tom: *"with a guide who's a teenager you walk around the place awake, not like in class. When people explain how things happen in a lively way, it makes the material more colorful, less dull… it's like: 'I'm the guide and I'm your friend, if you want to listen, listen.'"* This juxtaposition between the classroom and the museum was echoed by other participant, like Robbie, who pointed out that *"if you gave someone a choice between a pile of books and the museum, they would prefer the museum."*

These findings show the feasibility of creating a meaningful science learning environment within school were students can develop their scientific knowledge and skills in an interesting and fun way according their perception. Even though such learning environments may answer the needs of some of the students and not all student still it is of great value as will be discussed in the discussion section.

The finding also show the uniqueness of the Mini Science Museum as an environment that allows and enhances collaborative learning, positive and intensifying sense of belonging to a supportive community, belonging to a quality group of students that teach science in a fun way and contribute to the development of positive attitudes toward science among the public. The literature often emphasizes the contribution of collaboration and team work to understanding and meaningful learning (Silva, 2008; Wagner, 2014). Collaboration and communication are essential capabilities in the realm of science and are dominant skills in the 21st century skills qualifications (Larson & Miller, 2011). We will further elaborate on this in the discussion section.

To summarize the results, our findings revealed that the Mini Science Museum trustees who participated in this study, appreciate the opportunity given to them to act as guides, which empowers them cognitively, emotionally and practically: "*A place where I felt I could combine the things I like to do most ... a combination of my love of guiding and my love of science" (Talia)*. Unique conditions were created in the Mini-Museum that integrated the different needs of students. Joy said, *"Sometimes it was just clearing my head when I was messed up. You could come, open the door and sit down and deal with something that isn't you, isn't your life."* She added that it is *"a very small environment to work in – very flexible."*

The students demonstrated awareness of the program's contribution to their personal development and their social interactions. The students consider the Mini-Museum as a school framework that allows self-expression: *"I think this program is very important, first and foremost because it gives students from 8th grade and up a way to express themselves."(Idan).*

Summary and discussion

The main goal of this study was to assess the effectivity of the in-school Mini Science Museum as a meaningful learning environment for its trustees. We asked: What are the perceived personal gains and most important aspects of the Mini Science Museum from the viewpoint of its trustees? What characteristics turn the in school Mini Science Museum into a meaningful learning environment for its trustees?

The Grounded Theory approach was employed and inductive analysis of data collected from the eleven trustees revealed three main themes related to the effectivity of the in-school Mini Science Museum as a meaningful learning environment for its trustees: ***collaborative learning and guidance*** between the student trustees***;*** an environment that generates ***interest and pleasure***; an environment that increases students' ***self-efficacy and empowerment***. Each of these themes encompassed cognitive, emotive and practical aspects. These main themes and aspects convey that the students who volunteered in the museum portrayed their experience as overwhelmingly positive in a variety of ways. Many of the students noted that the Mini Museum environment served as a place where their love of science was not the exception but the norm. The Mini Science Museum served as a 'scientific home' some even used the word 'family'. Current research suggests that a sense of belonging in an academic context influences individuals in a variety of ways, increasing their academic motivation, their academic achievement, and their well-being (Anderman & Freeman 2004). Similar sense of belonging was evidenced also in the study presented here.

Our discussion will summarize the main characteristics of the Mini Science Museum as a meaningful learning environment for its trustees in order to illustrate a model of school initiative to create a scientific community for students who are interested in developing their scientific knowledge and skills. The particular characteristics that made up *this* community’s experience, and the specific benefits the museum seems to offer the trustees as they perceive and responded, are mapped out and discussed in more detail below.

Alternative, interesting and enjoyable learning environment

One of the main elements that draw the trustees to the museum is their shared interest in science and their desire to learn and to **teach** it. Working as the museum trustees exposed the students to diverse ways of learning about scientific phenomena. They learned during their visits and training at the museum, through independent learning as preparation before group visits, through participation in staff meetings, and by observing their peers during guided tours. Sjøberg and Schreiner (2008), claim that young people express their interest in science through diverse activities like visiting science centers and watching science programs.

The mini-museum trustees who participated in this study prominently expressed feelings of satisfaction, confidence and support. The word "fun" came up often in interviews. These positive expressions represent the fertile ground on which a sense of personal empowerment and growth in self-efficacy can develop, and may be due to a variety of factors like the non-formal atmosphere, the small size of the group, and the opportunities the museum provided for the students to express themselves, use and explore their own abilities.

Gogolin and Swartz (1992) noted that students' scientific knowledge and attitudes toward science are affected by the quality of their exposure to science. They elaborate that attitudes toward science change with exposure to science, but the direction of change may be related to the quality of that exposure. The quality of the exposure depends, among other factors, on the type of the instructional strategies students' encounter - instructional strategies that improve affective outcomes as well as achievement outcomes. Gogolin and Swartz (1992) recommend exposure to science that is highly structured; allow students to build their science self-concept; provide frequent feedback so students will know exactly how they are doing; allocate time for reflection and the opportunity to try again; measure affective outcomes as well as factual recall. They also contend that peer relationships may play a significant role in students' development. We would like to argue that the Mini Science Museum learning environment is characterized by a quality exposure to its trustees since it provides the above characteristics recommended as quality exposure to science (Gogolin & Swartz 1992). This quality exposure is evidenced by the trustees as was revealed in their responses in staff meetings and interviews and presented in our findings.

A key element in the success of the Mini Science Museum as a learning environment was the fact that all trustees were involved in the museum by choice. Such free choice is a powerful means of motivation and empowerment, as noted by Falk and Dierking (2000), who claim that free-choice learning in the science museum has potential advantages in nurturing curiosity and improving motivation and attitudes.

Another point mentioned by the interviewees was that they enjoyed introducing science to their visitors in a fun way and they appreciate the fact that the visitors enjoyed the museums' exhibition and activities. Rennie et al. (2010) found that the popular interactive science exhibits in their study were those that were apprehendable, competitive, noisy, or encouraged social interaction by engaging more than one person simultaneously- similar effect happened in the in-school Mini Science Museum in this study.

Students as teachers and leaders

Most of the students perceive the role of guiding as the “crowning glory” of the Mini Science Museum activities. In literature, practical experience and skills like talking to an audience, explaining difficult scientific principles or terms, leading a group of people, planning scientific activities, is perceived as more meaningful (Spektor-Levy, Scherz, & Eylon, 2009) and leaves a deeper imprint than learning in teacher-centered settings (Lutz & Huitt, 2004). The responsibility of preparing and leading a guided tour places the students at the center of their own learning process. Ramaswamy, Harris, and Tschirner (2001) investigated the effect of students teaching sessions in class. They reported that students benefited in-depth learning of the topic of their teaching session, as well as developing their presentation and teaching skills. The students in our study referred to their acquisition of such skills extensively, noting that they would be valuable in numerous ways in their future.

One source of empowerment mentioned relates to the status and appreciation of those who understand and teach physics. Science is perceived as a complicated, abstract subject in the community of learners at school (Duggan & Gott, 2002; Gunstone, McKittrick, & Mulhall, 1999; Osborne & Collins. 2000). Our interviewees expressed satisfaction with the fact that their scientific knowledge grew as a result of their time in the museum, and their self-esteem grew accordingly.

Furthermore, students reflect that it is the experience of standing in front of an audience during guided visits that improved their sense of efficacy. The students’ awareness of their position as role models to other students also contributed to their growing confidence. Incorporating opportunities for students to teach and to act as peer models is considered highly effective because students are most likely to increase their own self-efficacy when observing a model of similar ability level performing the skill (Schunk, 1987).

In-school scientific community of practice

The working and learning experience the trustees describe is that of a community of practice. Researchers have been interested in developing a community of practice in educational settings, as a framework to understand how individuals learn. Yet there are few studies that explore and document the potential dynamics that determine whether or not a community of practice emerges within school settings (Olitsky, 2007).

Collaboration of all forms is increasingly seen as an essential and important part of education (Schraw, Crippen, & Hartley, 2006). Over the past decades, socio-cultural models of learning such as situated learning theory (Lave & Wegner 1991), cognitive apprenticeships (Collins, Brown, & Newman, 1989), and the work of Vygotsky (1978) have played a prominent role in educational research and practice. In the context of our study, the learning experience in the museum corresponds to the constructivist approach (Vygotsky, 1978). The fundamental strategy for learning was peer teaching, which took the form of two types of mentoring. First, the trustees serve as instructors for younger students who visit in the museum. But no less importantly, peer teaching takes place among the trustee staff, with more experienced students instructing and mentoring younger, novice trustees.

This model of collaborative learning and peer teaching combines students of different learning levels, and facilitates the development of scientific knowledge in the museum community of practice. Peer teaching has been widely used in education. There is extensive evidence that peer learning and teaching is effective for a wide array of goals and content (Topping, 2005), and that cooperative learning settings promote positive interpersonal growth (Ramaswamy, Harris, & Tschirner, 2001).

Peer collaboration provides an opportunity for the explicit discussion of scientific concepts and for reflection, which promotes metacognition and self-regulation. It encourages inquiry, the utilization of strategies, the development and sharing of mental models, and making explicit of personal beliefs (Schraw, Crippen, & Hartley, 2006). The success of the peer teaching in our study supports the claims of Barton and Tan (2010), who emphasized the need to provide children/youth with opportunities to engage with science in ways that meaningfully blend the world of science with students' social worlds.

Trujillo and Tanner (2014) explored three affective constructs that are important for understanding students' science learning: self-efficacy, sense of belonging, and science identity (the extent to which a person is recognized or recognizes himself or herself as a “science person”). All three of these constructs, in addition to other cognitive and social constructs, were strongly manifested in the in-school Mini Science Museum reality described in this paper.

The opportunity to engage with peers and explore together is an invaluable activity that encourages learning for everyone in the group (Yoon, et al. 2013). The results of our study demonstrate the great benefits to be gained by favoring programs designed for a particular, limited audience that attends out of personal choice, and the desire to be surrounded by others with similar interests and goals. In such situations, a significant social connection can occur, based on the common goals of the learners in the population. This connection allows for individual growth within the context of a heterogeneous group of equals (Wenger, 1998).

The informal learning environment of the Mini-Museum provided its trustees with the various factors that according to Brown, Collins, and Duguid (1989) constitute meaningful learning: collaboration, reflection, coaching, multiple practices, articulation of strategies and cognitive apprenticeship. The participation in such a culture of practice (Lave & Wenger, 1991) allows novice trustees first to observe elder and experienced trustees from the boundary, or in other words to engage in "legitimate peripheral participation," then, as their learning and involvement in the culture increases, the trustees move from the role of observer to that of fully functioning agent (Herrington & Oliver, 1995). They gradually become more active and immersed in the social community, and their role changes from that of 'beginner' to that of 'expert.'

Falk and Dierking (2013) emphasize that museums are, at their core, social institutions. Falk and Dierking mainly relate to the different types of visitors (frequent, occasional and nonparticipants; family groups, etc.) and how they interact, how they behave in museum galleries, and how they interrelate as they share information and personal experiences in museum spaces. Falk and Dierking elaborate that these processes are food for thought. Following our study we suggest relating to the trustees of the in-school Mini Science Museum also as a social group that like the visitors interrelate as they share information and personal experiences in the museum spaces and build their own community of practice. This desired outcome is also food for thought.

Järvelä, Volet, and Järvenoja (2010) claim that in collaborative learning, individual group members represent interdependent self-regulating agents (cognitive angle) who at the same time constitute a social entity that creates affordances and constraints for engagement in the activity (situative angle). The situative angle is composed of social construction, motivation and cognitive angle, which taps into the mediating role of individual members' metacognitive reflections and interpretations (Järvelä, Volet, & Järvenoja, 2010).

Furthermore, collaboration and team work is one of the main 21st century skills qualifications (Larson & Miller, 2011).Thus, the framework of the in-school Mini Science Museum provide a fertile ground to explicit acquisition of skills that are defined as crucial for future studies and employment of today's school students (Kivunja, 2014; Silva, 2008).

Conclusions

Our study of the in-school Mini Science Museum and its impact on trustees demonstrates that such learning environments are feasible in school. Even though such framework may not answer the needs of all students in school, it may answer the needs of students who want to study more science and who are motivated to teach others. Schools can provide frameworks that enhance students' sense of empowerment in cognitive, emotive and practical dimensions. Frameworks that develop positive attitudes toward science and scaffold the development of a supportive, collaborative, community of learners. Adopting this form of learning would not just enrich the students' experience of learning in the present, but might send them out into the world with a greater sense of their own competence and confidence.

However, further research should be undertaken. One goal that would be served by such additional research would be to increase the size of the sample. Although we applied qualitative approach, a larger sample would have significantly improved the accuracy of any attempts to generalize from our conclusions.

It is also advised to look for other in-school mini-museum (although as far as the authors explored there is no such innovation in our country and rarely in other countries) or similar programs to examine and compare similar settings within different contexts. Typifying students within the sample population may clarify our understanding of the consequences of participation in similar programs on students.

Additionally, longitudinal research could be undertaken to examine changes in scientific knowledge, learning achievements, self-efficacy and attitudes toward science over time among the students, as well as the effect of participating in the program on JHS students' decision to major in science in high school.

To conclude, analysis of the perceived personal gains and most important aspects of the Mini Science Museum from the viewpoint of its trustees allowed us to identify what characteristics turn the in-school Mini Science Museum into a meaningful learning environment for its trustees. Our findings shed light on the feasibility and effectivity of the in-school Mini Science Museum or similar in-school initiatives to provide a meaningful learning environment for school students who volunteer and run those initiatives.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Ornit Spektor-Levy, PhD in science education, Lecturer in the School of Education, Bar Ilan University, Israel.

Oshra Aloni, has MA in science education, the School of Education, Bar Ilan University, Israel.

Michal Zion, PhD in Life Science, Professor in the School of Education, Bar Ilan University, Israel.

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