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THE ROLE OF INFORMAL SCIENCE CENTERS IN SCIENCE EDUCATION: ATTITUDES, SKILLS, AND SELF-EFFICACY

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Abstract

Informal learning relates to activities that occur outside the school environment. These learning environments, such as visits to science centers provide valuable motivational opportunities for students to learn science. The purpose of this study was to investigate the role of the pre-academic center in science education and particularly to explore its effects on 750 middle-school students' attitudes toward science, their scientific thinking skills and self-efficacy. Pre and post-case based questionnaires were designed to assess the students' higher order thinking skills – inquiry, graphing, and argumentation. In addition, a five-point Likert scale questionnaire was used to assess students' attitudes and self-efficacy. The research results indicated a positive effect of the pre-academic science center activities on scientific thinking skills. A significant improvement in the students' inquiry and graphing skills was found, yet non significant differences were found in argumentation skill. The students significantly improved their ability to ask research questions based on reading a scientific text, and to describe and analyze research results that were presented graphically. While no significant differences were found between girls and boys in the pre-questionnaire, in the post-questionnaire the girls' scores in inquiry skill were significantly higher than boys' scores. Increases in students' positive attitudes toward science and self-efficacy were found but the results were not statistically significant. However, the program length was found to be an important variable that affects achievement of educational goals. A three-dimension-based framework is suggested to characterize learning environments: organizational, psychological, and pedagogical.

Keywords – Informal learning, Learning visit, Science center, Attitudes toward science, Scientific thinking skills, Self-efficacy.

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1 INTRODUCTION AND THEORETICAL BACKGROUND

Students' achievements in the sciences have received ongoing attention over the past decade as demonstrated by inter national large-scale standardized testing efforts (Gonzales, Williams, Jocelyn, Roey, Kastberg, & Brenwald, 2008; OECD, 2014). The decreasing interest in science among youth in both primary and secondary educational systems has been widely reported and documented. Many students think science is too hard, uninteresting, and irrelevant (Aschbacher, Ing & Tsai, 2013). As a result the number of young people choosing to study sciences at universities and colleges is dropping. Students' science identities and goals have been influenced by their science experiences and expectations at home and in school (Aschbacher, Li & Roth, 2010). In recent years, efforts have focused on fostering science education and many on-going initiatives contribute to the renewal of science education; nevertheless, they are often small-scale (Kearney, 2010). The Michel Rocard

Report of 2007 summarizes the obstacles for youth to consider pursuing any career in science: traditional, deductive educational approaches in teaching science are boring and render the scientific content rather incomprehensible and unattractive. The report concludes that this is even more the case in secondary than in primary education, due to pressures of the school curriculum. Since career opportunities are seriously considered in the latter stages of secondary school, the current state of affairs is extremely worrisome. One of the main recommendations of the report is that novel teaching methods and especially inquiry-based educational approaches are called for.

Several studies have investigated students' attitudes toward science in order to overcome obstructions in learning science and technology. A number of variables have been examined: instructional design, gender, self-efficacy, interest, and achievements (Abrahams, 2009; Jarvis & Pell, 2005; Raghavan, Sartoris & Glaser, 1998; Selçuk, Şahin & Açıkgöz, 2011; Snir & Smith, 1995; Trumper, 2006). Larson, Stephen, Bonitz and Wu (2014) investigated the role of self-reported effort in predicting science achievements. They argue that students are strongly motivated to work hard, and achievement is attributed more to effort than to ability.

Krapp and Prenzel (2011) argued that interest is a parallel concept to attitude, rather than a subcategory of it. The strongest predictor of students' science, engineering or mathematics interests in grades 7 to 9 is the question of confidence as a science learner (Aschbacher et al., 2010). Powerful opportunities that allow students to see what real scientists do, try their hand at it, and realize that they can do it, are most important as a means to affect students' attitudes or interests. Unfortunately, such opportunities are rare among school students therefore; extracurricular opportunities with authentic science activities outside of school are needed.

One of the academic science centers in Israel dedicated to this goal is the Sidney Warren Science Education Center for Youth at Tel-Hai College. The center, as a pre-academic framework, aims at strengthening the potential of school students in order to encourage them to pursue higher education, with an emphasis on science and technology studies. The center provides students with hands-on laboratory experience and computerized learning environments not available in their schools (Sasson & Cohen, 2013). The cooperation with an academic and research institute creates an opportunity for meetings with experts as role models in science. The activities encourage educational continuity in order to promote excellence in science and technology that will naturally encourage students to continue their education, in general, and to specialize in the sciences, in particular.

The purpose of this study is to investigate the role of the pre-academic center in science education and particularly, to explore its effects on student attitudes toward science, their scientific thinking skills and self-efficacy. The paper presents a method to measure students' thinking skills by science case-studies. This evaluation method is usually rare in informal learning environments like science centers. The theoretical background will first focus on informal learning environments in general and science centers in particular in order to characterize the main features of the Sidney Warren Science Education Center for Youth. Then, a review of the assessment methods that are usually used in science centers will be presented with emphasis on the special variables that are at the focus of this study. As will be shown in the discussion section the paper calls for re-examination of the relevance of the definitions of formal and informal learning environments. Usually the focus in science centers is on the psychological aspects of learning like interest, attitudes and feelings of confidence in learning science. This paper presents a research that combines psychological and pedagogical evaluations in order to demonstrate more attention to pedagogical aspects in science center activities.

1.1 Informal Learning Environments and Science Centers

Distinctions are usually made between formal and informal learning, suggesting that learning that occurs in school is different from learning out of school, for example, in a museum (Anderson, Thomas & Ellenbogen, 2003; Hofstein & Rosenfeld, 1996).

Informal learning relates to activities that occur outside the school environment, which have been developed in response to the needs of the school and the demands of the curriculum. These activities are characterized by the fact that participation is not mandatory and experiences are not assessed using scores as they are in school. Informal learning experiences can be structured to achieve different objectives and can influence attitudes or change behavior (Crane, Nicholson & Chen, 1994; Hofstein & Rosenfeld, 1996).

Rodari (2009) published a review based on the work of 14 specialists who analyzed hundreds of documents on pedagogical practices concerning informal scientific education. They concluded that in informal contexts, participants: enjoy interesting, involving and stimulating experiences, and are motivated to acquire new knowledge on the phenomena of the physical and natural world; they are able to produce, understand, recall and use explanations, arguments, models and facts related to science; manipulate, test, explore, predict, observe and give sense to the physical and natural world; reflect on science as a way to learn; on its processes, concepts and institutions; they reflect on their own learning process; participate in scientific and practical learning activities along with other people, using scientific terminology and specific tools; they think of themselves as people learning science and thus build an identity as persons who know, use and sometimes contribute to the production of scientific knowledge.

Informal learning often involves field trips. A field trip is a tour organized by the school for educational purposes during which students experience materials and training methods based on observable and direct investigations (Hofstein & Rosenfeld, 1996; Krepel & Durall, 1981). Learning in a tour is informal learning in that it is less systematic and structured and more flexible. It depends on learners' self-motivation and is a hand-on experience in real contexts, involving considerable cooperation and sharing (Cainey, Bowker, Humphrey & Murray, 2012; Cheng & Ho, 2011).

Science museums are institutions of knowledge, places of collecting, seeing and knowing evidence of science while science centers are more typically concerned with presenting universal abstract laws, principles, and phenomena (MacDonald, 1998).

Koster (1999) suggested seven attributes for science centers of which four refer to the instructional design of the science activities:

- a mission centering on integrated interpretations of science-technology-society (STS) issues;
- a dedication to providing access and outreach to visitors and users of all ages, learning styles, and backgrounds;
- a unifying theme that helps to create context and connections for visitors; 4) adoption of available multimedia to create engaging experiences.

The literature indicates some classifications of science centers. Janousek (2000) classified museums and science centers into two types:

- traditional and object-oriented. Collections and exhibitions are based on artifacts with no presentation of a broader context;
- focus on elucidating the natural order of the universe and exhibits are interactive.

Wellington (1998) describes two types of exhibits usually found at the science centers: experiential exhibits that allow the visitor to experience and interact with science phenomena; and the pedagogical exhibit that sets out to teach something. Pedretti (2002) defines a third category - critical exhibitions that focus on the processes of science, the nature of science, and science and technology in its sociocultural context.

The pre-academic science center, the Sidney Warren Science Education Center for Youth, creates media for communicating science to the public with the focus on school groups. The center offers field visits in advanced labs, providing special equipment and materials in several science topics: biotechnology, nutrition and food technologies, chemistry, physics, environmental science, mathematics, and computer science. One of the main goals is creating a strong foundation for close collaborations between academic experts, researchers, and school systems as a means of building a self-image among young students as science learners or as being able to make science. Based on Wellington's (1998) and Pedretti's (2002) classification, activities are focused on pedagogical and critical aspects. Scientific programs involve children from kindergarten to 12th grade, and are based on three major educational approaches that cut across all the programs:

- the constructivist approach which views learning as an active process that constructs meanings in the learners' minds. Learning environments that are based on this approach have been found particularly beneficial to students by enhancing their learning processes (Rivet & Krajcik, 2004; Rosenfeld & Rosenfeld, 2006; Dori & Sasson, 2008; Von Glasersfeld, 1991);
- the inquiry-based approach which encourages cooperative learning through which the student gains experience with formulating questions, constructing a set of experiments, gathering data and drawing conclusions. Research indicates that this method fosters students' ability to think in diverse ways, to develop creativity and independence in learning, to awaken curiosity and wonder, to develop generally positive attitudes towards learning and to improve scholastic achievements (Haury, 1993; Kühne, 1995; Shulman & Tamir, 1973); and

- the Enrichment Triad Model (Renzulli, 1979; Renzulli & Reis, 2000) which is based on three stages: exposure, deepening knowledge and skills, and research.

1.2 Assessment of the Learning Processes in the Science Centers

Informal learning environments, such as visits to science centers provide valuable motivational opportunities for students to learn science. These environments can have an impact on learning while addressing aspects of science education that might be missing in more formal, class-based science learning environments. Enrichment activities in science centers are perceived as an opportunity to increase students' interest in learning but the question of cognitive value is unclear. Studies have reported a range of gains in cognitive learning and positive science-related attitudes as outcomes of visits to science centers, but the findings for cognitive and affective changes are not always consistent Jarvis and Pell (2002) asserted that "it might be questioned whether such short experiences have value". They found that "only relatively few children develop a greater enthusiasm for science and for being scientists" (p. 981). Bozdoğan and Yalçın (2009), on the other hand, reported an increase in interest in science and an improvement in academic achievement after a visit to a science exhibition center in Turkey. According to Anderson, Lucas, Ginns and Dierking (2000) and Jarvis and Pell (2005), meaningful learning processes during out-of-school experiences are influenced by pre-visit, in-visit, and post-visit activities. Falk and Dierking (1992) suggested that the visit experience depends on interaction among three contexts:

- the visitors' own personal backgrounds of knowledge, experiences, skills, motivations, and desires,
- the social interactions during the visit, and
- the physical environment created by the center surroundings.

Price and Hein (1991) defined educationally effective programs as those "in which products are not emphasized, inquiry is sparked, open-ended questions are generated, and students actively participate and appear involved" (p. 510).

Falk, Scott, Dierking, Rennie and Cohen (2004) call for studies that examine learning as shifts in attitudes, values, beliefs, understandings and skills. As such, the purpose of this study is to investigate the effect of the pre-academic science center on students' attitudes toward science, their scientific thinking skills and self-efficacy.

2 RESEARCH SETTINGS

Attitudes toward science, self-efficacy, and scientific thinking skills were assessed among 750 middle-school students who participated in the science center activities during 2012-2013. Two main programs were selected for this investigation in which science inquiry was emphasized in the instructional design. About 600 students participated in the "Science Research Program" that focuses on developing science thinking skills by research experience. The students gain experience in scientific research and prepare a science poster as a final learning product. The program follows the research process; beginning with exposure to a science phenomenon, formulation of questions, experiment planning, data collection, presentation of results and drawing of conclusions. Students work in small groups during the research process. Each group receives about 50 academic hours per year. All science topics are new for the students but still related to the school science curriculum. The students' science teachers from their schools also participate in the activities at the college in order to generate the appropriate connections to the school curriculum.

About 150 students participated in the "Preparation for Academia Program" which includes an initial introductory period in mathematics and science and then the participants are encouraged to take part in regular college classes and gain academic credits or to conduct a high-level science project as part of their school matriculation exams (based on Ministry of Education approval). Each group receives about 120 academic hours per year. Most of the students in both of the programs are talented students who learn special science classes in their schools in.

2.1 Science Thinking Skills Assessment

Based on Dori and Sasson (2008) and Sasson and Dori (2006, 2011), pre- and post case-based questionnaires were designed to assess the students' higher order-thinking skills.

A case study is a learning tool presented in a narrative way that deals with real situations. The use of case studies features several themes: cases as a tool for professional preparation and development, cases for facilitating critical thinking and exploring dilemmas, and cases as an assessment tool (Dori, 2003; Dori & Herscovitz, 1999, 2005; Dori & Sasson, 2008; Sasson & Dori, 2011; Tal & Hochberg, 2003; Tobin, Kahle, & Fraser, 1990). Pre and post case-based questionnaires were designed to assess three thinking skills: inquiry, graphing, and argumentation. The questionnaires included a variety of assignments for assessing these thinking skills.

In the inquiry assignment, students were asked to formulate a research question, based on the scientific text they received, and to define its variables (dependent and independent). In the graphic assignment they were asked to describe the graphs and to analyze data and reach logical conclusions. The argumentation assignment tested students' ability to present a scientific claim based on relevant explanations and examples.

For each assignment, an assessment rubric was conducted and validated by five experts in science education achieving 90% inter-rater reliability.

Table 1 presents an example of one of the rubrics that was used to assess students' ability to formulate a research question, based on the scientific text, and to define its variables.

Score	***Criteria***
0	*No answer, inquiry question is not relevant or not presenting the right structure – effect of variable A on B*
1	*The inquiry question is relevant to the scientific text and presents the right structure – effect of variable A on B **or** the question presents an innovative aspect that wasn't presented directly by the scientific text*
2	*The inquiry question is relevant to the scientific text and presents the right structure – effect of variable A on B **and** the question presents an innovative aspect that wasn't presented directly by the scientific text*

Table 1. Rubric for assessing students' inquiry skill

Students were asked to fill out the case-based questionnaire twice, at the beginning of the program and at the end. Table 2 presents students details.

Time	***N***	***Girls***	***Boys***	***7th grade***	***8th grade***	***9th grade***	***Secular***	***Religious***
Pre	*438*	*45%*	*55%*	*32%*	*49%*	*19%*	*80%*	*20%*
Post	*646*	*53%*	*47%*	*49%*	*45%*	*6%*	*83%*	*17%*

Table 2. Students' details- Science thinking skills

2.2 Attitudes toward Science and Self-efficacy Assessment

To measure attitudes toward science and self-efficacy, a five-point Likert scale was used based on CARS - Changes in Attitudes about the Relevance of Science questionnaire (Jarvis & Pell, 2002; Pintrich, Smith, Garcia & McKeachie, 1991; Siegel & Ranney, 2003). The questionnaire included 13 statements (e.g., "I am interested in doing science in the future", "I enjoy science classes", "I feel that I have what is needed to succeed in science studies", "I like to solve hard riddles"). The students were required to choose one of the five options for each statement: 5. ''strongly agree,'' 4. ''agree,'' 3. ''undecided,'' 2. ''disagree,'' 1. ''strongly disagree.'' The Cronbach alpha reliability coefficients for the attitudes toward science was a = .862; self-efficacy, a = .797.

Students were asked to fill out the questionnaire twice, at the beginning of the program and at the end. Table 3 presents students details.

Time	*N*	*Girls*	*Boys*	*7th grade*	*8th grade*	*9th grade*	*Secular*	*Religious*
Pre	*592*	*43%*	*57%*	*46%*	*35%*	*19%*	*74%*	*26%*
Post	*440*	*44%*	*56%*	*24%*	*49%*	*17%*	*75%*	*25%*

Table 3. Students' details – Attitudes and self-efficacy

3 FINDINGS

Based on the rubrics that were developed students' responses to the pre- and post case-based questionnaires were assessed and the scores were calculated for each thinking skill. Table 4 represents students' scores in the thinking skills that were assessed.

Thinking skill	*Pre N=438*		*Post N=646*		*t Test*
	Mean	*S.D*	*Mean*	*S.D*	
Inquiry skill (Min=0, Max=2)	*0.67*	*0.65*	*0.99*	*1.46*	*t=-4.85 p=0.000*
Graphing skills (Min=0, Max=2)	*0.96*	*0.67*	*1.16*	*0.63*	*t=-4.92 p=0.000*
Argumentation skill (Min=0, Max=2)	*1.14*	*0.87*	*1.22*	*0.86*	*n.s.*

n.s. = Non-significant

Table 4. Students' thinking skills results – pre vs. post

The results indicate a significant improvement in the students' inquiry and graphing skills. The students significantly improved their ability to ask research questions based on reading a scientific text, and to describe and analyze research results that are presented graphically. Non-significant differences were found in argumentation skill.

The next step in analyzing the results examined whether there are differences between sub-groups in the research population in each thinking skill. No significant differences were found between girls and boys in the pre-questionnaire while in the post-questionnaire, the girls' scores in inquiry skill were significantly higher than the boys' scores (mean1=1.01, S.D1=0.72, mean2=0.85, S.D2=0.69, t=-2.59, p<0.01). Religious students' scores on the inquiry skill were significantly higher than secular students' scores in the pre-questionnaire (mean1=0.85, S.D1=0.78, mean2=0.62, S.D2=0.68, t=-2.42, p<0.001). However, in the post-questionnaire, non-significant differences were found in this thinking skill, but an advantage in the graphing skill was found in favor of the secular student' scores (mean1=1.22, S.D1=0.65, mean2=0.90, S.D2=0.45, t=5.83, p=0.000). The next examination focused on a comparison between the pre-questionnaire scores of the 7th grade students who participated in the science center programs for the first time and the 8th and 9th grade students who had participated in the programs during the previous academic year as well. Results are presented in Table 5.

Thinking skill	*New students N=138*		*Senior students N=300*		*t Test*
	Mean	*S.D*	*Mean*	*S.D*	
Inquiry skill (Min=0, Max=2)	*0.46*	*0.62*	*0.76*	*0.65*	*t=-4.50 p=0.000*
Graphing skills (Min=0, Max=2)	*0.71*	*0.63*	*1.08*	*0.65*	*t=-5.40 p=0.000*
Argumentation skill (Min=0, Max=2)	*1.16*	*0.92*	*1.14*	*0.85*	*n.s.*

n.s. = Non-significant

Table 5. Students' thinking skills results- senior students vs. new

Students' attitudes toward science and self-efficacy were investigated for both students in the "Science Research Program" and the "Preparation for Academia Program". An increase in students' mean scores was found but the results were not statistically significant as presented in Table 6.

	Pre N=745		***Post N=475***		***t Test***
	Mean	***S.D***	***Mean***	***S.D***	
Attitudes toward science (Min=1, Max=5)	*3.72*	*0.91*	*3.79*	*0.92*	*n.s*
Self-efficacy (Min=1, Max=5)	*4.03*	*0.65*	*4.05*	*0.73*	*n.s*

n.s. = Non-significant

Table 6. Students' attitudes and self-efficacy results- pre vs. post

The next step in analyzing the results examined whether there are differences between sub-groups in the research population in respect to attitudes toward science and self-efficacy. Non-significant differences were found between boys and girls, secular and religious students and senior-experianced and new students in the pre-and the post-questionnaires. A comparison was made between the two programs. The results are presented in Table 7.

	"Preparation for Academia Program" N=132		***"Science Research Program" N=343***		***t Test***
	Mean	***S.D***	***Mean***	***S.D***	
Attitudes toward science (Min=1, Max=5)	*4.15*	*0.87*	*3.64*	*0.89*	*t=-5.61 p=0.000*
Self-efficacy (Min=1, Max=5)	*4.16*	*0.68*	*3.97*	*0.74*	*t=-2.55 p<0.05*

Table 7. Students' attitudes and self-efficacy results-
"Preparation for Academia Program" vs. "Science Research Program"

The results indicate a significant advantage in attitudes and self-efficacy scores in favor of the students who participated in the "Preparation for Academia Program" in contrast to students who participated in the "Science Research Program".

4 DISCUSSION

The purpose of this paper was to investigate the learning process of the Sidney Warren Science Education Center for Youth as a pre-academic science center. The specific goals were to examine effects on students' attitudes toward science, their scientific thinking skills and self-efficacy. To reach these goals, pre-and post-case-based questionnaires and pre-and post-attitudes and self-efficacy questionnaires were used among 750 middle-school students.

The students' scores in all thinking skills were relatively low in the pre-questionnaire and were average in the post-questionnaire. The research results indicated a positive effect of the academic science center activities on scientific thinking skills. A significant improvement in the students' inquiry and graphing skills was found. The students significantly improved their ability to ask research questions based on reading scientific texts, and to describe and analyze research results that were presented graphically. Activity design in the Sidney Warren Science Education Center for Youth is based on the inquiry-based approach; therefore, this explicit instruction method encourages cooperative learning through which the student gains experience in formulating questions, constructing a set of experiments, gathering data and drawing conclusions. Yet, non-significant differences were found in argumentation skill. Explicit instruction for developing argumentation skill has not been used although students were asked to design a science poster as a final product of the learning process. We can assume that special intervention was needed in order to develop this skill as presented in earlier studies (Simon, Johnson, Cavellt & Parsons, 2011; Schworm & Renkl, 2007; Yoon, Elinich, Wang, Steinmeier & Van Schooneveld, 2012; Zohar & Nemet, 2002). When students are assisted in becoming aware of their own learning processes (metacognition), they gain much richer understandings of the content of their learning (Thomas & McRobbie, 2001). Instructional design that is focused on providing awareness of science learning processes will help students to develop richer cognitive understandings of the science topics that are presented in science centers and help them in becoming more empowered life long learners.

The National Science Education Standards describes inquiry as a "set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories" (National Research Council, 1996, 214). Educational efforts intended to enhance science education and engaging students in scientific inquiries at all grade levels is a critical component of supporting their understanding of the practices and nature of science (Duschl, Schweingruber & Shouse, 2007). Nevertheless, classroom inquiry remains a rare event (Abrams, Southerland & Evans, 2008). Research results strengthen early findings that informal learning environments can play a significant role in promoting science education and particularly in the implementation of inquiry-based methods (Marty et al., 2013; Yoon et al., 2012).

While no significant differences were found between girls and boys in the pre-questionnaire, in the post-questionnaire the girls' scores in inquiry skill were significantly higher than boys' scores. Science skills and factors relating to learning experiences have been associated with gender differences (Linn & Pulos, 1983). Girls' experiences in science and math differ from those of boys, causing a low level of confidence among girls (Linn, 1980a, 1980b). Curriculum and teaching methods affect girls' interest in science (Häussler & Hoffmann, 2002; Jones & Young, 1995; Jarvis & Pell, 2005; Kelly, 1987). Positive attitudes affect achievement in science, especially for girls (Häussler & Hoffmann, 2002; Osborne, Simon & Collins, 2003). Lorenzo, Crouch and Mazur (2006) suggested eight strategies to narrow the gender gap in class. These strategies include:

- creating an interactive environment that enhances cooperation among the students;
- alternating between group discussion and structured teaching—females perform better when they are able to articulate their thoughts verbally, and males perform better when their learning experience is structured; and
- engaging in activities that decrease competitiveness.

Based on the results of this research, we can assume that the inquiry-based method might narrow the gaps between boys and girls and even enable an advantage for girls. This assumption is in line with Hoffmann (2002) who found that girls are more interested in natural phenomena and practical applications of theoretical concepts.

Hands-on science centers offer an opportunity to develop students' attitudes to science, stimulating curiosity, inventiveness, and respect for evidence (Braund, 2004). In this research, students' attitudes toward science and self-efficacy were investigated for both students in the "Science Research Program" and the "Preparation for Academia Program". The students' results were relatively positive both in the pre-and the post-questionnaires. An increase in students' mean scores was found but the results were not statistically significant. However, the results indicate a significant advantage in attitudes and self-efficacy scores in favor of the students who participated in the "Preparation for Academia Program" versus students who participated in the "Science Research Program". The two programs are based on the same pedagogical principles but the main difference is in their lengths. The program "Preparation for Academia Program" is longer (120 academic hours instead of 50). We can assume that the program length is an important variable that effects achievement of educational goals. The students who participated in these programs were talented and study in special science classes in their schools. This might have contributed to their relatively positive initial attitudes toward science and self-efficacy and thus their relative improvement in these variables was low.

The concepts of formal and informal learning have been dealt with extensively in the literature (Anderson et al., 2003; Crane et al., 1994; Hofstein & Rosenfeld, 1996; Jarvis, 2004; La Belle; 1982; Rennie & Mclafferty, 1995; Rodari, 2009). Falk (2001) introduced the framework of free choice learning to replace the concepts informal and non-formal learning. The idea of free choice emphasizes the unique nature of out-of-school environments that allow the learner to identify several learning options. Mocker and Spear (1982) claimed that the degree of formality is the extent to which a learner has control over both the objectives and the means of learning. According to their model, in formal learning, institutions have control over both objectives and means. In non-formal learning, the learner controls the objectives, but the institution controls the means. In informal learning, the institution controls the objectives, but the learner controls the means; while in self-directed learning, the learner controls both objectives and means.

Re-examination of the relevance of the definitions of formal and informal learning environments is required. Free-choice learning may occur in all educational modes; the formal, and the informal. Dohn (2010) distinguishes between the psychological level and the organizational level of formality and claims that there are significant elements of formal learning in informal situations and elements of informality in formal situations.

Another category is required forming a three-dimension-based framework to characterize learning environments: organizational, psychological, and pedagogical. Informal learning environments are characterized by independence of the educational system; therefore they usually have different organizational modes. With reference to the organizational mode of education science centers and museums may be described as informal learning environments providing learning activities outside the school. Reference to the psychological and pedagogical aspects in the informal learning environment may be similar to those in the formal environment. Each learning environment should be characterized by the main attributes based on these three dimensions. This theoretical framework will contribute to natural relations between learning situations. Experiences in informal settings, like museums and science centers, have the potential to produce knowledge and understanding if visitors are able to draw connections with their own prior knowledge and are able to see connections with life experiences, in the classroom or in any other experiential aspect of life. This is in line with Hofstein and Rosenfeld (1996) who have importantly recommended that "future research in science education should focus on how to effectively blend informal and formal learning experiences in order to significantly enhance the learning of science" (p. 107).

More attention to pedagogical aspects in science center activities is needed. Usually the focus is on the psychological aspects like interest, attitudes and feelings of confidence in learning science. Bradburne (1998) critiques that science centers which focus their activities on displays about science and scientific principles, manifest three major weaknesses:

- they misrepresent the nature of scientific research;
- they focus on principles and phenomena rather than processes; and
- they show science out of context rather than as experienced by visitors.

Science center must move from a focus on artifacts to an emphasis on education, from didactics to empowering the implementation of pedagogical principles.

This paper has presented an investigation of two dimensions- the psychological and the pedagogical facets of the Sidney Warren Science Education Center for Youth at Tel-Hai College. The research suffers from some limitations. Only quantitative research tools were used. It is important to combine qualitative tools like interviews to get a better understanding of students' perceptions about learning processes. In addition, it would be interesting to compare students' perceptions of science learning in school to learning in the science center. Despite its limitations, this research has made several contributions. The research contributes to both the theoretical and the practical facets of the educational system. The study is likely to provide deeper understanding of the nature of student achievements in the field of science. In educational theory, a contribution is expected to the general body of knowledge dealing with evaluation in education and, more specifically, in researching the relationship between opportunities for learning and results. The article emphasizes by an example of a deep investigation the importance of understanding different design features in the learning environments that affect pedagogical and psychological aspects of learning. With regard to practice, it provides a broad understanding of supplemental science programs and their contribution toward advancing the science achievements of students. In addition, analysis of successful cases enables deeper understanding of the important characteristics for efficient implementation of pedagogical resources necessary to bring about the desired results in learning. These characteristics will become the basis for formulating a model to guide the successful operation of science programs for effective cooperation between formal and informal learning environments based on shared educational goals.

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