ENHANCING STUDENTS' MOTIVATION TO LEARN CHEMISTRY

Yamit Sharaabi-Naor
yamitsharaabi@yahoo.com | Weizmann Institute of Science, Israel

Miri Kesner
Miri.Kesner@weizmann.ac.il | Weizmann Institute of Science, Israel

Yael Shwartz
yael.shwartz@weizmann.ac.il | Weizmann Institute of Science, Israel

ABSTRACT

The interest, attitudes, and motivation of students towards science learning decreases over time, especially during the middle school years. In order to increase students' motivation to learn chemistry, a national program «Chemistry, Industry, and the Environment in the eyes of the individual and society» has been designed to integrate three main components: (1) a competition format; (2) a context-based approach, and (3) Project-based learning (PBL). Literature supports the effectiveness of each approach in enhancing students' motivation. In this study we evaluated how the combination of these approaches influenced students' motivation to learn chemistry. In addition, we evaluated a similar project that took place in a single school. The comparison took into account students' characteristics regarding their intrinsic motivation to study chemistry as a subject in general and the nature of the project. We found that the national project increases students' motivation to learn chemistry, whereas a similar project that takes place in school does not have the same effect. Nevertheless, we noticed a small decline in interest throughout the project. Once again, this research provides additional evidence of the complexity of motivational processes.

KEY WORDS

Competition; Motivation; High-school; Chemistry.

SISYPHUS
JOURNAL OF EDUCATION
VOLUME 2, ISSUE 2,
2014, PP. 100-123

Enhancing Students' Motivation to Learn Chemistry

Yamit Sharaabi-Naor | Miri Kesner | Yael Shwartz

THEORETICAL BACKGROUND

Motivation affects students' learning and engagement in formal, semi-formal, and informal activities. Already in 1993, it was suggested that we should turn our attention towards motivation more than we have done before (Pintrich, Marx & Boyle, 1993). Many studies in science education investigated students' motivation by examining cognitive and affective constructs (Koballa & Glynn, 2007; Logan & Skamp, 2008; Milner, Ben-Zvi & Hofstein, 1987; Shernoff & Hoogstra, 2001).

Different definitions of motivation and theoretical frameworks have been offered by researchers and practitioners in the area. *However, most researchers agree that* «Motivation is the process whereby goal-directed activity is instigated and sustained» (Schunk, Pintrich & Meece, 2008, p. 5). Motivation is a process rather than a product. As a process, we do not observe motivation directly but rather we infer it from actions (e.g., choice of tasks, effort, and persistence) and verbalizations (e.g., «I really want to work on this»). Motivation involves both physical and mental activity. Physical activity entails effort, persistence, and other overt actions. Mental activity includes such cognitive actions as planning, rehearsing, organizing, monitoring, making decisions, solving problems, and assessing progress. Most activities that students engage in are geared toward attaining their goals. There are several different theories that are suggested in the literature that try to define and explain the nature of motivating students involved in academic contexts. We present here short examples of the four leading motivational theories in the field of education: (1) *Self-determination* theory is directed to «the process of students utilizing their will» (Deci, 1980, p. 26). In *Self-determination* theory students must decide how to act on their environment according to their basic innate psychological needs such as a sense of relatedness, ability, and autonomy in order to be internally motivated (Deci, Vallerand, Pelletier & Ryan, 1991). (2) *Attribution* theories assume that individuals are motivated to understand and master their world and will try to determine the causes of events (Kelley, 1971). In an achievement context, the most important event is achieving success or failure, and attribution theory proposes that individuals' attributions will have significant consequences on the motivational process. In Attribution theory, two general categories can influence students' attributions for success and failure: environmental (social norms and other situational features) and personal factors (casual schema, attributional bias, prior knowledge, and individual differences) (Weiner, 1986, 1995). (3) *Achievement goal* theory mainly focuses on the goal orientation in the context of the academic behaviour of students. This theory specifies two main goal orientations: mastery goals orientation, and performance goals orientation. Mastery goals orientation refers to an individual's purpose of developing competence, understanding, and skills or achieving a sense of mastery (Ames, 1992). Performance goals orientation refers to the purpose of demonstrating competence. Performance-oriented students are concerned with others' perceptions of their competence and with their ability relative to others (Ames, 1992; Nicholls, 1984). (4) *Expectancy Value* theory takes into consideration students' perceptions of the value of the task combined with their expectation to succeed in it (Eccles et al., 1983). In our research we examined students' motivation mainly through the eyes of the Expectancy Value theory; hence, in our description we elaborate more about this theory. Expectancy Value theory has two central variables such as *Expectancies* and *Values*. The expectancy construct is one of the most important mediators of achievement behaviour. *Expectancies* are individuals' beliefs and judgments about their capabilities to perform a task successfully. Most individuals will not choose a task, or continue to engage in it when they expect to fail. In colloquial terms, expectancy answers the question: «Can I do this task?» (Eccles, 1993, 2005; Eccles, Wigfield & Schiefele, 1998; Pintrich, 1988a, 1988b; Wigfield, 1994; Wigfield & Eccles, 1992, 2002). If the answer is «yes», then most students will choose to engage in the task. *Values* – they refer to the beliefs students have about the reasons why they might engage in a task. Students might have a variety of reasons why they want to perform a task. Eccles et al. (1983) proposed four major components of subjective values: (1) Attainment value or importance – the importance of doing well on a given task. (2) Intrinsic value – the enjoyment or intellectual satisfaction that one gains from doing the task. (3) Utility value or usefulness of the task – how a task fits into an individual's future plans, for instance, participating in a chemistry project to fulfil a school or teacher's requirement, or to decide whether to enrol in a chemistry class in the future. (4) Cost belief – what the individual believes that he/she has to give up while performing a task (e.g., do I spend too much time working on the project instead of spending time with my friend?), as well as the anticipated effort one needs in order to complete the task.

Expectancy Value theory has had a long-standing tradition in achievement/motivation research, and current expectancy-value models have had some of the strongest empirical support in educational settings (Eccles, 1987, 1993, 2005; Eccles et al., 1983; Wigfield, 1994; Wigfield & Eccles, 1992, 2000, 2002; Wigfield, Eccles & Rodriguez, 1998; Wigfield, Tonks & Eccles, 2004). We utilized expectancy value theory for investigating students' motivation to learn chemistry by engaging them in a national competitive project.

Recently, studies have shown that the interest, attitudes, and motivation of students towards learning science decline toward the end of elementary school and especially during the middle school years (Anderman & Young, 1994; Galton, 2009; Osborne, Simon & Collins, 2003; Simpson & Oliver, 1990; Vedder-Weiss & Fortus, 2011). In order to overcome this problem, new trends have emerged that have influenced chemistry teaching throughout the world. These trends attempt to create an appropriate curriculum suitable for general education in chemistry, and for increasing the popularity of chemistry learning. In the next section we describe two leading approaches that positively influence the teaching and learning of science, as documented by many researchers. However, the literature also points out that each approach separately is insufficient to address all needs and challenges of science teaching and learning. Accordingly, in this paper we will present a program that blends these two well-known approaches in such a way that utilizes their benefits, and minimizes the disadvantages each has individually.

THE CONTEXT-BASED APPROACH

A very popular approach in chemistry education is the context-based approach (Gilbert, 2006; Pilot & Bulte, 2006), in which the scientific content is embedded in authentic contexts that show students the importance and relevance of science, for improving their own life, and also show how scientific methods and products can be applied (Gilbert, 2006; Bulte & Pilot, 2006). However, several disadvantages of using this approach were reported. For example, students still exhibited a decrease in interest, especially in physics and chemistry. This can be explained by the fact that in many cases, the contexts were chosen by the teacher or the curriculum developer, and not by the students. Video studies have shown that teaching and learning styles are teacher dominated, and do not allow students to develop their own ideas. In other words, students did not have enough autonomy in their learning process nor in choosing the subject of their interest inside a fixed context (Graeber, 1995; PISA consortium, 2007).

PROJECT-BASED LEARNING

Another popular approach related to science teaching and learning is Project-based learning (PBL). Project-based learning (PBL) is a model that organizes learning around projects. According to the definitions found in PBL handbooks for teachers, projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; they give students an opportunity to work relatively autonomously over extended periods of time, and this results in realistic products or presentations (Jones, Rasmussen & Moffitt, 1997; Thomas, Mergendoller & Michaelson, 1999). Other features of PBL found in the literature include authentic content, authentic assessment, teacher facilitation but not direction, explicit educational goals (Moursund, 1999), cooperative learning, reflection, and incorporation of adult skills (Diehl, Grobe, Lopez & Cabral, 1999; Thomas, 2000). In PBL, usually there are questions or problems that «drive» students to encounter (and struggle with) the central concepts and principles of science. The central activities of the project involve the construction of knowledge by the students. PBL projects require much more student autonomy, choice, unsupervised work time, and responsibility than traditional instruction does. These are all characteristics that give the students a feeling of authenticity and ownership.

The PBL approach is well known for its beneřts for students (Knoll, 1997; Koschmann, 2001; Krajcik & Blumenfeld, 2006; Krajcik, Blumenfeld, Marx & Soloway, 1994; Rosenfeld & Fallik, 2002; Ruopp, Gal, Drayton & Přster, 1993; Thomas, 2000; Thomas, Mergendoller & Michaelson, 1999; Tinker, 1997). The research literature shows that students who engage in PBL develop skills of independent learning (including problem-solving), they learn to be more open minded, remember what they learn longer, and perform better on standard achievement tests than non-PBL students do. These findings were demonstrated for PBL (Blumenfeld, Krajcik, Marx & Soloway, 1994; Ladewski, Krajcik & Harvey 1994; Marx et al., 1994, 1997, 2004; Rivet & Krajcik, 2004; Schneider, Krajcik, Marx & Soloway, 2002), and for design-based science (DBS) (Fortus, Dershimer, Krajcik, Marx & Mamlok-Naaman, 2004). From a motivational point of view, Project-Based Learning designs are viewed as maximizing students' orientation toward learning and mastery. This could be mainly due to their emphasis on student autonomy, collaborative learning, and assessments based on authentic performances. In practice, Project-Based Learning designers have incorporated additional features such as variety, challenge, student choice, and non-school-like problems in order to promote students' interest and perceived value (Blumenfeld et al., 1991).

COMPETITIONS IN SCIENCE EDUCATION

The project reported in this paper is in a framework of a contextualized PBL, and took place in the context of a national competition. Our decision to choose the framework of a competition is supported by several studies, which consider competitions as an acceptable way to increase students' motivation for learning science. Competitions are popular all over the world. The chemistry international Olympiads are aimed at high-school honour students, and are mainly based on scientific content knowledge. For example, in the «Internet-symposium» 16-17 year-old students from several schools carry out a chemistry experiment and discuss their research (Internetsymposiom, 2010). Also, the «FameLab» (2010) competition is intended for graduate students who are requested to speak about scientific topics within three minutes. The IUPAC internet site (2010) also suggests a few ideas about competitions for the International Year of Chemistry 2011. This includes an essay competition «Chemistry-our life, our future», and an international pictures contest «Everything is Chemistry».

In this paper we present our findings regarding how the national competition-PBL design affected students' motivation to learn chemistry. We collected students' retrospective perceptions on their experience of learning chemistry as part of being engaged in the 'national project'. In addition, we compared these perceptions with the perceptions of another group of students that were engaged in a similar project that took place at school, named 'the school project'. This comparison better emphasizes the characteristics that a PBL design should have in order to achieve its goals of increasing students' motivation to learn chemistry while they are engaged in performing the project.

CONTEXT OF STUDY: DESCRIPTION OF THE NATIONAL PROJECT «CHEMISTRY, INDUSTRY, AND THE ENVIRONMENT IN THE EYES OF THE INDIVIDUAL AND SOCIETY»

According to the education literature, students are more motivated to study the subject matter when they find it more relevant to their lives and to the society in which they live (Bennett & Lubben, 2006). The organizers of the project found that it is important to emphasize the relevance of chemistry to daily life in order to make chemistry studies more meaningful to the students (Frailich, Kesner & Hofstein, 2007; Hofstein & Kesner, 2006; Kesner, Hofstein & Ben-Zvi, 1997). It is apparent that this context provides a very wide area of interest to the students, and allows them a high degree of freedom to choose their own subject of interest. In addition, utilizing the PBL approach enables the learning to be more student-centred and teacher facilitated instead of teacher guided. In this way, students can be more involved in the learning process and can enjoy their choice of interest inside the context-based learning.

The first round of this national competition took place in 2008. High-school students from all over the country were invited to take part in various projects, all of which are aimed at highlighting the importance and relevance of chemistry and its influence on individuals and to society.

Five parallel competitions were offered, namely: Preparing a short video; Preparing a poster; Preparing a newspaper article; Presenting a laboratory inquiry; Only in 2008: Solving a monthly riddle; Starting 2009: Preparing a photograph. The students present an artistic photograph of a phenomenon (related to chemistry), accompanied by a scientific explanation of the photographed phenomenon.

Each competition had different assessment criteria according to its unique product, but all of them required that proper scientific background and relevance to daily life be included. At the end of the project, students submitted their work for assessment. Those who prepared posters or laboratory inquiries were also asked to present a five-minute-verbal presentation in front of the judges.

THE UNIQUENESS OF THE NATIONAL PROJECT

The uniqueness of the project can be characterized as follows:

- It calls for the participation of high-school students at all levels (not only the students who take chemistry as a major).
- The fact that the project is based on a wide context area increases the students' degree of freedom in choosing a subject of their interest.
- Since the national competition is a PBL, it incorporates a good deal more student autonomy, choice, unsupervised work time, and responsibility than traditional instruction does. This also may have a positive effect on students' experiences, and they might enjoy the learning process more, and increase their internal motivation to learn chemistry.
- It offers ongoing mentors facilitation, both online and face-to-face.
- The students can meet and receive support and advice from experts in the relevant fields; these experts include scientists from chemical companies and science educators.
- Students are encouraged to participate in a one-day seminar (held in three regions) in which they participate in different workshops according to the type of product they are aiming at.
- The competitions promote peer collaboration - the chemistry students can involve students who major in other areas such as communication and multimedia according to the projects' requirements.
- The various competitions allow students with different learning styles and abilities to participate. They can prepare a specific type of product according to their interests, abilities, and talents.

- The project uses a formative assessment approach: There is a follow up process in which the outlines and interim products are checked and commented on if needed. The embedded assessment ensures that the students undergo a meaningful learning process, and helps in obtaining high-level students' products.
- All students who reach the final stage of the competition participate in a one-day national conference in which they present their work to their colleagues; they can choose their own unique way of presentation.
- The competition format enables students who reach the final stages to receive recognition for their work, and serve as their school representative. This may give students the feeling that they have a meaningful impact on their school image, and they may change their self-efficacy.

PROJECT PARTICIPANTS

Year	No. of students participating in projects	No. of students who reached the final stage	No. of participating schools that reached the final stage
2008-2009	220*	115	22
2009-2010	250	150	25
2010-2011	700	165	26
2011-2012	650	170	30

* Not including the monthly riddle.

Table 1 includes the national projects' participants over the years.

TABLE I — NUMBER OF PARTICIPANTS OVER THE YEARS

During the first two years the number of participants continued to grow slowly; however, two years later it started to grow significantly. This growth over the years serves as an indicator to the success of the national project.

SOME EXAMPLES OF STUDENTS' PROJECTS

Some students conducted *lab inquiries* on a variety of topics such as the effect of wine acidity on its colour; how do flame retardants, which are incorporated in different types of clothing, affect combustion; investigating the reaction between Coca-Cola and Mentos, as well as fermentation. Students created short *videos* on polymers, Dead Sea products, olive-oil production and its nutritional benefits, global warming, and others. Examples of newspaper *reports* are recycling, Chemistry in police work, and Chemistry used for our beauty. Examples of *Posters* topics are: Chemistry of love, acid rain, and how fuel can be obtained from water.

These examples demonstrate both the wide range of topics that students chose to focus on, as well as the socio-scientific aspects found in all the topics.

THE STUDY

The research took place in 2011-2012. Research design included the assessment of various components derived from the Expectancy-Value theory, and students' perception of a career in chemistry. We devoted a significant part of the research to the intrinsic value derived from the Expectancy-Value theory, since we consider it to be a good indicator that enables us to compare students' intrinsic motivation to learn chemistry by engaging in a project, and by approaching chemistry-related fields in their free time.

All motivational constructs were examined in two frameworks: (1) in the 'National project' competition, characterized by a free choice participation and took place in the Davidson Institute (in the Weizmann Institute of Science) and (2) in a similar 'school project' competition, in which participation was obligatory. The type of products and the assessment criteria for the 'school project' were similar to those of the national project; except that the school project was organized and facilitated by their chemistry teacher and was included in their chemistry formal scores at the end of their school year.

We examined students' perceptions of the experience of learning chemistry while they engaged in the projects, and we investigated, following their engagement in the project, whether students' motivation to learn chemistry increased.

Since the students that participate in a 'national project' freely chose to participate in it, we tended to think that they engaged in the activity for their own benefits and this falls into the authentic definition of intrinsic motivation. In the case of the 'school project', despite the fact that students were obligated to participate in the project, it was interesting to determine whether they still were internally motivated. We used this group as a control group relative to the national group. In order to overcome the possible differences in intrinsic motivation, we extracted from the two populations two sub-groups that were similar in their intrinsic motivation for *'chemistry learning at school'* and for *'approaching* *chemistry contents in general in their free time*' and compared their motivation to be engaged in the project. This will be presented in detail in the Results section.

RESEARCH GOALS AND QUESTIONS

Our main purpose was to evaluate how the 'National project' motivationally influenced chemistry learning for students. We addressed this question by collecting students' retrospective perceptions of their experience in learning chemistry through their engagement in the 'national project'. The fact that the 'national project' took place in an academic institute outside school might enhance students' motivation to learn chemistry more than if they were engaged in such a project at school. We compared the retrospective perceptions for their learning experience in the 'school project' with those received for the 'national project'.

An additional way to evaluate the success of the project is by comparing the 'intrinsic motivation' of students to learn chemistry, following their engagement in a project, with their motivation to approach chemistry contents in their free time. Hence, we examined (for each individual student) the value of 'intrinsic motivation' for chemistry learning via engaging in the project relative to that of being self-engaged in chemistry contents in general in their free time. These comparisons were conducted in both population groups: the 'national project' and the 'school project' students).

Based on the above goals, our research questions are as follows:

1) How does the 'national project' motivationally influence students to learn chemistry?
2) Are there differences in students' intrinsic motivation (for learning chemistry) while they engage in the project, relative to when they choose to be self-engaged in it on their free time and will?

RESEARCH POPULATION

'National project' Experimental group	*'School project' Control group*
N=116	N=52

TABLE 2 – RESEARCH POPULATION; STUDENTS WHO PARTICIPATED IN THE EVALUATION RESEARCH 2011-2012

Table 2 describes the two groups that were studied in the current study.

RESEARCH TOOLS

(1) A Likert-type questionnaire (1-5 scale) was developed for assessing various motivation categories. The categories were defined once for 'chemistry learning within the project', and once for 'chemistry subject in general'. The categories for 'chemistry learning within the project' are as follows: interest, enjoyment, easiness/difficulty, importance of doing well in a given task, and effort. The categories for students' perception of chemistry as a subject are as follows: interest and enjoyment while approaching chemistry contents in their free time and chemistry as a future career. The questionnaire was validated by 3 science-education researchers. Internal reliability, obtained by calculating the α-cronbach coefficient for each category, is presented in Table 3.

Category	Alpha Cronbach	No. of items	Example of an item
Chemistry in General			
Interest (free time)*	0.83	5	Chemistry-related issues evoke my curiosity
Career	0.88	5	It is possible that I'll choose a career in chemistry
Project			
Interest	0.86	6	To what extent did the chemistry project evoke your curiosity?
Enjoyment	0.8	4	Learning chemistry by engaging in the project was fun
Easiness /Difficulty	0.71	4	Learning the subject matter was easy when engaging in the project
Importance	0.85	5	It is important for me to succeed in the project
Effort	0.72	4	I made a big effort in order to succeed in the project

*This reflects students' interest when they engage in chemistry in their free time.

TABLE 3 – α-CRONBACH COEFFICIENT OF CATEGORIES

(2) An open-ended questionnaire allowed us to gather information regarding why students participated in the 'national project' (or in other words the utility value), the way students conducted their research, the kind of assistance that they used (or needed), some reflections regarding their learning

throughout the project, and whether the project influenced their attitude towards chemistry as a subject.

(3) 15 reflective interviews were conducted regarding students' experience and their desire to learn chemistry following their project and school studies. Triangulation was obtained by the three data sources – the Likert-type questionnaire, the open-ended questions, and interviews.

DATA COLLECTION & ANALYSIS

Lykert questionnaire: The value of 'Interest' was examined at the beginning and end times of the project (September and March 2012, respectively), all other values (such as enjoyment or difficulty) were examined at the end of the project. The mean score for each category was calculated and a paired t-test procedure was completed for comparing the students' motivation categories (or specific item) for the 'school project' or 'national project'.

The open-ended questionnaire: Students' answers were categorized according to the subject questioned. Then, all answers belong to a specific category were pooled to form a list of citations. Trends were observed and were used to support and explain data emerging from the Likert-type questionnaire.

Reflective interviews: The interviews were open in nature: students were asked to describe their experience and the process they underwent. Students talked freely and their answers were audio recorded, and transcribed. The transcripts were divided into sections by common categories. The categories emerged from students' answers. Also here, the interviews were utilized to better understand the results and to validly interpret the results.

RESULTS AND DISCUSSION

(1) How does the 'National project' motivationally influence the students' learning of chemistry?

By the end of the '*National project*' or '*school project*' we collected student's retrospective perceptions for their chemistry learning via engagement in the national project. These are presented in Table 4. Table 4 shows relatively high mean scores for all motivation categories related to the '*national project*'. All means are scored above the median (3 out of 5). The results are quite different for the '*school project*'. They had significantly lower scores than those engaged in the 'national project' in most motivational categories related to the project. This picture is reflected from all categories relating to the project except for a single category referring to 'Easiness /Difficulty'. Since both groups have similar scores for the 'Easiness/Difficulty' category (average of 3.7 in both groups in favour of chemistry being perceived as 'easy'), we claim that the '*Easiness / Difficulty' category* does not have a meaningful contribution to the differences observed in students' motivation for learning chemistry via the '*national project' relative to the 'school project*'. Our results may be interpreted as showing that the 'national project' has more of an effect on students' motivation for chemistry learning than the 'school project'. However, this effect may not be attributed only to the nature of the project.

Category	'National project' Mean	'School Project' Mean	Pr > |t|
Chemistry in general [1]			
Interest (free time)	3.3	2.8	0.0016
Career	3.2	2.1	<.0001
Project [2]			
Interest	3.6	2.3	<.0001
Enjoyment	4.0	2.9	<.0001
Effort	3.5	2.4	<.0001
Importance	4.5	3.6	<.0001
Easiness /Difficulty	3.7	3.7	NS

[1] These categories assessed the way students perceive chemistry in their free time.
[2] These categories assessed chemistry learning via students engaging in the project.

TABLE 4 – MEAN SCORES OF DIFFERENT MOTIVATION CATEGORIES FOR THE EXPERIMENTAL ('NATIONAL PROJECT') AND CONTROL ('SCHOOL PROJECT') GROUP

It might have something to do with the difference between the two populations regarding students' intrinsic motivation to learn chemistry in general. Our results show significant differences in students' motivation to approach chemistry contents in their free time for the 'national project' compared with the 'school project' population (Table 4). It appears that students that engage in the 'national project' have significantly greater interest in approaching chemistry contents in their free time than those engaging in the 'school project». Moreover, students engaging in the 'National project' reported that they are more interested in a chemistry career than those who engaged in the 'school project' (Table 4). These results may suggest that students that participated in the 'national project' were more intrinsically motivated than those who engaged in the 'school project'. In addition, the fact that students chose to participate in the 'national project', and were not obligated to do so by their teachers, could also contribute to the their greater enhancement in motivation that was observed for students participating in the 'national project' relative to 'school project'. Information gathered from interviews shed more light on how the populations of the *'national project' and the 'school project'* were motivated. It appears that they differ from each other not only regarding their motivation to be engaged in the project, but also in the way they perceive chemistry in general. Students from *'the national project'* exhibited positive attitudes for chemistry in general and for the project in particular, for example, some said:

> Chemistry is a subject that always interested me (…)
> I always liked chemistry (…)
> I enjoyed learning by myself; it is a subject of my choice.

In the case of the *'school project'* we did not observe that students spontaneously favoured chemistry, and we even observed negative impressions regarding the project itself. A sample quote:

> I think it is not fun to do a project in general(…) Since it demands investment in time which most students lack.

Considering all of the above, one can easily doubt the conclusion that the '*National project*' had more of an influence on students' motivation to learn chemistry compared with the *'school project'*. The differences in motivation may result from differences between both populations regarding their intrinsic motivation to study chemistry in general. In order to focus only on the impact that the 'national project' has on students' motivation to learn chemistry, we searched for a statistical way to eliminate the impact related to the differences in intrinsic motivation seen between both populations.

We statistically extracted two new subgroups that were similar in their intrinsic motivation, once for *chemistry learning at school* and once for *approaching chemistry contents in general in their free time*. Intrinsic motivation contains the *Interest* and *Enjoyment* values (data presented in Table 5). To achieve that, we excluded all students with scores above 3.5 in these categories from the 'national project' population. We now had two groups with no significant difference in their intrinsic motivation (see Table 5). For these two new groups, we again compared all motivational categories related to the project (see Table 6).

Category	'School Project' Mean	'National project' Mean	Pr > |t|
*Intrinsic motivation <Chemistry>**	*2.56*	*2.57*	*N.S*
*Intrinsic motivation <school>***	*2.99*	*2.87*	*N.S*

* This category includes items relating to students' interest and enjoyment of chemistry in their free time.
** This category includes items relating to students' interest and enjoyment of chemistry learning at school.

TABLE 5 – MEAN SCORES OF *INTRINSIC MOTIVATION* DATA CALCULATED FOR A CHARACTERISTIC SAMPLE BELONGING TO THE EXPERIMENTAL ('NATIONAL PROJECT') AND CONTROL ('SCHOOL PROJECT') GROUP. THE CHARACTERISTIC SAMPLES EXCLUDED DATA THAT WERE ABOVE 3.5

Category	'School project' <Mean>	'National project' <Mean>	'School project' /'National project'
Interest	2.32	3.148	<.0001
Enjoyment	2.847	3.613	<.0001
*Intrinsic motivation <project>**	2.531	3.337	<.0001
Effort	2.399	3.344	<.0001
Importance	3.625	4.311	<.0001
Easiness /Difficulty	3.71	3.554	N.S
Career	2.086	2.629	0.0079

* This category includes items relating to students' interest in and enjoyment of learning chemistry after engaging in a project.

TABLE 6 – MEAN SCORES OF DIFFERENT MOTIVATION CATEGORIES FOR THE CHARACTERISTICS OF THE EXPERIMENTAL ('NATIONAL PROJECT') AND CONTROL ('SCHOOL PROJECT') GROUP. THE CHARACTERISTICS ARE PRESENTED IN TABLE 5

Apparently there are significant differences in most motivational categories between the 'national project' relative to the 'school project', besides the '*Easiness /Difficulty* category. Even though we created two groups that have similar intrinsic motivation to study chemistry in general and for learning chemistry at school, our results did not change and explicitly show that the motivation to learn chemistry is significantly greater for those in the ‘National project’. Finally, we can clearly state that the ‘national project’ increases students’ motivation to learn chemistry significantly more than the ‘school project’.

(2) *Are there differences in students’ intrinsic motivation (for learning chemistry) while they engage in the project, relative to when they choose to be self-engaged on their free time and will?*

An additional way to evaluate the success of the project is by comparing students’ intrinsic motivation to learn chemistry within the project to their intrinsic motivation to approach chemistry contents in their free time. We compared the values of interest and enjoyment that constitute the intrinsic motivation component. This comparison was done within each population separately (‘national project’ and ‘school project’). Table 7 shows the results of this comparison.

Category	‘National project’ <Mean>			‘School Project’ <Mean>		
	Chemistry	Project	Pr > |t|	Chemistry	Project	Pr > |t|
Intrinsic motivation	3.25	3.72	<.0001	2.56	2.53	NS

TABLE 7 – MEAN SCORES OF THE INTRINSIC MOTIVATION (ENJOYMENT & INTEREST ITEMS) TOWARDS CHEMISTRY IN GENERAL AND SPECIFICALLY IN THE PROJECT

It appears that students of the ‘national project’ group have significantly higher ‘intrinsic motivation’ for chemistry learning both within the project and when they are self-engaged with chemistry contents in their free time.

However, there is no difference in the ‘school project’ group regarding their motivation to learn chemistry within the project and in their free time. Their intrinsic motivation in both cases is quite similar (and low), whereas students’ intrinsic motivation to participate in the national project is significantly greater than when they are involved in chemistry in their free time. This means that there is a need for a structured framework and deadlines; this establishes a delicate balance between this need and the freedom and choice that the project should provide.

Here are some examples derived from students' reports, which support our conclusion:

1. In the case of the 'national project', students reported that it is more exciting to do the project in a research institute or an industrial facility (providing that they receive scientific, professional, and social support).

   I enjoyed the experience of going to the university and investigating the subject more deeply.

   I mostly enjoyed the interview I conducted with a doctor for nuclear medicine, meeting with professional people, elaborating my knowledge by learning new contents and working with industrial companies»

2. Students participating in the 'national project' had a chance to meet other students coming from different schools across the country and to present their work to each other. As a result, students undergo an extraordinary positive experience socially and emotionally.

   I enjoyed doing experiments related to my subject of choice and from presenting our project to other students we met.

Our main conclusion is that the national project enhances students' motivation for learning chemistry and significantly contributed to students in terms of interest, enjoyment, and importance. Students' motivation was found to be higher regarding their engagement in the 'national project' framework compared with a 'school project' framework, which was less successful. Interestingly, students' intrinsic motivation for learning chemistry is higher through engagement in the national project, and lower when they are self-engaged in chemistry contents in general in their free time, which implies the importance of an external framework. Here are some supporting quotes:

> During the project, I found out how interesting chemistry can be and I learned about new phenomena. (Interest)

> Chemistry is a much more complex subject than I previously taught. (Difficulty)

> The teamwork increased my enthusiasm for chemistry learning (Motivation)

Following a question: «Would you consider participating again next year»? Students mainly responded:

> Yes, it reflects my interests. I am curious to deal with another subject.

> Yes, it helped me better understand the lessons at school.

As was discussed in the introduction, the research literature shows that students who engage in PBL develop skills of independent learning, learn to be more open minded, remember what they learn longer, and perform better on standard achievement tests than do non-PBL students. Our research adds an additional perspective of how the national project (considered as a PBL), which takes place outside of school, contributes to students' motivation to learn chemistry. We showed here that the national project increases students' motivation to be engaged in learning chemistry, whereas a similar project that takes place within school does not have the same effect. Apparently, students participating in the 'school project' did not experience the project's unique atmosphere, especially the social interactions with experts and students from other schools, as experienced by the students of the national project.

In the future, we would like to better understand how school can enhance and maintain students' motivation to learn chemistry after they engage in the project. For example, students often reported that pressure from the school daily demands damages their functioning in the project. Since the project is time consuming, this time should be recognized by schools as a time of learning, and as such, it may replace a topic that is traditionally taught in class. As a consequence, schools may allow more time for, and put less pressure on students dealing with the project. An authentic collaboration between schools and external educational institutions should be established and implemented in order to promote students' motivation to be engaged in such a project, and to increase continuum motivation through the project as well.

ACKNOWLEDGMENTS

We would like to thank CIL, for funding the project's activities since 2008, and we wish to thank Ms. Karen Siem for her kind support, which enabled us to conduct research related to the project.

REFERENCES

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, *84*, 261-271.

Anderman, E. M., & Young, A. J. (1994). Motivation and strategy use in science: Individual differences and classroom effects. *Journal of Research in Science Teaching*, *31*(8), 811-831.

Bennett, J., & Lubben, F. (2006). Context-based Chemistry: The Salters approach. *International Journal of Science Education*, *28*(9), 953-956.

Blumenfeld, P. C., Krajcik, J. S., Marx, R. W., & Soloway, E. (1994). Lessons learned: How collaboration helped middle grade science teachers learn project-based instruction. *The Elementary School Journal*, *94*, 539-551.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: sustaining the doing, supporting the learning. *Educational Psychologist*, *26*, 369-398.

Deci, E. L. (1980). *The psychology of self-determination*. Lexington, MA: D. C. Heath.

Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: The self-determination perspective. *Educational Psychologist*, *26*(3), 325-346.

Diehl, W., Grobe, T., Lopez, H., & Cabral, C. (1999). *Project-based learning: A strategy for teaching and learning*. Boston, MA: Center for Youth Development and Education, Corporation for Business, Work, and Learning.

Eccles, J. S. (1987). Gender roles and woman's achievement related decisions. *Psychology of women Quarterly*, *11*, 135-172.

Eccles, J. S. (1993). School and family effects on the ontogeny of children's interest, self-perceptions, and activity choice. In J. Jacobs (Ed.), *Nebraska symposium on motivation: Developmental perspectives on motivation* (pp. 145-208). Lincoln, NE: University of Nebraska Press.

Eccles, J. S. (2005). Subjective task value and the Eccles et al. *Model of achievement-related choices*. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105-121). New York: Guilford Press.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75-146). San Francisco, CA: W. H. Freeman.

Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology:* Vol. 3. Social' emotional, and personality development (5^{th} ed., pp. 1017-1095). New York: Wiley.

Fortus, D., Dershimer, R. C., Krajcik, J., Marx, R. W., & Mamlok–Naaman, R. (2004). Design-based science and student learning. *Journal of Research in Science Teaching*, *41*(10), 1081-1110.

Frailich, M., Kesner, M., & Hofstein, A. (2007). The influence of web-based chemistry learning on student's perceptions, attitudes, and achievements. *Research in Science & Technology Education*, *25*(2), 179-197.

Galton, M. (2009). Moving to secondary school: Initial encounters and their effects. *Perspectives on Education (Primary Secondary Transfer in Science)*, *2*, 5-21.

Gilbert, J. (2006). On the nature of «context» in chemical education. *International Journal of Science Education*, *28*(9), 957-976.

Graeber, W. (1995). Interests of students and accounting for that in STS education: Results of an empirical study in chemical education]. *Empirische Pädagogik*, *9*, 221-238.

Hofstein, A., & Kesner, M. (2006). Industrial Chemistry and school chemistry: Making chemistry studies more relevant. *International Journal of Science Education*, 28(9), 1041-1062.

Jones, B. F., Rasmussen, C. M., & Moffitt, M. C. (1997). *Real-life problem solving: A collaborative approach to interdisciplinary learning.* Washington, DC: American Psychological Association.

Kelley, H. H. (1971). *Attributions in social interactions.* Morristown, NJ: General Learning Press.

Kesner, M., Hofstein, A., & Ben-Zvi, R. (1997). Student and teacher perceptions of industrial chemistry case studies. *International Journal of Science Education*, *19*(6), 725-738.

Knoll, M. (1997). The project method: Its vocational education origin and international development. *Journal of Industrial Teacher Education*, *34*(3), 59-80.

Koballa, T. R. J., & Glynn, S. M. (2007). Attitudinal and motivational constructs in science learning. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 75-102). Mahwah, New Jersey and London: Lawrence Erlbaum Associates Publishers.

Koschmann, T. (2001). Dewey's contribution to a standard of problem-based learning practice. In P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds.), *European perspectives on computer supported collaborative learning* (pp. 356-363). Maastricht, The Netherlands: Maastricht McLuhan Institute.

Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based science. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 317-334). New York: Cambridge.

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., & Soloway, E. (1994). A collaborative model for helping middle grade science teachers learn project-based instruction. *The Elementary School Journal*, *94*, 483-497.

Ladewski, B. G., Krajcik, J. S., & Harvey, C. L. (1994). A middle grade science teacher's emerging understanding of project-based instruction. *The Elementary School Journal*, *94*, 499-515.

Logan, M., & Skamp, K. (2008). Engaging students in science across the primary secondary interface: Listening to the students' voice. *Research in Science Education*, *38*(4), 501-527.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Blunk, M., Crawford, B., Kelly, B., et al. (1994). Enacting project-based science: Experiences of four middle grade teachers. *The Elementary School Journal*, *94*, 517-538.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., et al. (2004). Inquiry based science in the middle grades: Assessment of learning in urban system reform. *Journal of Research in Science Teaching*, *41*, 1063-1080.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1997). Enacting project-based science: Challenges for practice and policy. *Elementary School Journal*, *97*, 341-358.

Milner, N., Ben-Zvi, R., & Hofstein, A. (1987). Variables that affect students' enrolment in science courses. *Research in Science and Technological Education*, *5*(2), 201-208.

Moursund, D. (1999). *Project-based learning using information technology.* Eugene, OR: International Society for Technology in Education.

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, *91*(3), 328-346.

Osborne, J. A., Simon, S. B., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079.

Pilot, A., & Bulte, A. (2006). Why Do You «Need to Know»? Context-based education. *International Journal of Science Education*, *28*(9), 1017-1039.

Pintrich, P. R. (1988a). A process-oriented view of student motivation and cognition. In J. Stark & L. Mets (Eds.), *Improving teaching and learning through research: New directions for institutional research*, 57 (pp. 65-79). San Francisco: Jossey-Bass.

Pintrich, P. R. (1988b). Student learning and college teaching. In R. Young & K. Eble (Eds.), *College teaching and learning: Preparing for new commitments: New directions for teaching and learning*, 33 (pp. 71-86). San Francisco: Jossey-Bass.

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63(2), 167-199.

Rivet, A. E., & Krajcik, J. S. (2004). Achieving standards in urban systemic reform: An example of a sixth grade project-based science curriculum. *Journal of Research in Science Teaching*, *41*, 669-692.

Rosenfeld, S., & Fallik, O. (2002). *Project-based learning in science and technology: A teacher handbook*. Israel: Weizmann Institute of Science and the Ministry of Education. (In Hebrew.)

Ruopp, R., Gal, S., Drayton, B., & Přster, M. (Eds.) (1993). *LabNet: Toward a community of practice*. Hillsdale, NJ: Erlbaum.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory, research and application*. Upper Saddle River, New Jersey and Colombus, Ohio: Pearson.

Schneider, R. M., Krajcik, J., Marx, R. W., & Soloway, E. (2002). Performance of students in project based science classrooms on a national measure of science achievement. *Journal of Research in Science Teaching*, *39*, 410-422.

Shernoff, D. J., & Hoogstra, L. (2001). Continuing motivation beyond the high school classroom. *New Directions for Child and Adolescent Development*, *93*, 73-88.

Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education*, *74*(1), 1-18.

Thomas, J. W. (2000). *A review of research on project-based learning.* Autodesk Foundation PBL. Retrieved from http://www.bie.org/index.php/site/resource/item27/.

Thomas, J. W., Mergendoller, J. R., & Michaelson, A. (1999). *Project-based learning: A handbook for middle and high school teachers*. Novato, CA: The Buck Institute for Education.

Tinker, B. (1997). *Thinking about science*. Unpublished manuscript. Retrieved from http://archive.concord.org/publications/pdf/ThAbSci.pdf.

Vedder-Weiss, D., & Fortus, D. (2011). Adolescents' Declining Motivation to Learn Science: Inevitable or Not? *Journal of Research in Science Teaching, 48*(2), 199-216.

Weiner, B. (1986). *An attributional theory of motivation and emotion*. New York: Springer-Verlag.

Weiner, B. (1995). *Judgments of responsibility: A foundation for a theory of social conduct*. New York: Guilford Press.

Wigfield, A. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review*, 6, 49-78.

Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, *12*, 265-310.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68-81.

Wigfield, A., & Eccles, J. S. (2002). The development of competence beliefs, expectancies for success, and achievement values from childhood through adolescence. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 91-120). San Diego: Academic Press.

Wigfield, A., Eccles, J. S., & Rodriguez, D. (1998). The development of children's motivation in school contexts. *Review of Research in Education*, *23*, 73-118.

Wigfield, A., Tonks, S., & Eccles, J. S. (2004). Expectancy value theory in cross-cultural perspective. In D. M. Mclnerney & S. Van Etten (Eds.), *Big theories revisited* (pp. 165-198). Greenwich, CT: Information Age Publishing.

SITES

Famelab: http://famelab.org/home.html

Internetsymposium: http://www.pieternieuwland.nl/Menu_Items/Projecten/Symposium/index.html

PISA consortium: http://www.pisa.oecd.org

IUPAC: http://www.chemistry2011.org

*

Received: February 20, 2014
Final version received: April 18, 2014
Published online: June 28, 2014