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The Effect of a Socio-Scientific Context-Based Science Teaching Program on Motivational Aspects of the Learning Environment

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Abstract

This paper reports about the effect of an innovative, context-based science teaching and learning program on student intrinsic motivation. The intervention aimed at promoting Inquiry-Based Science Education (IBSE) in close collaboration with teachers throughout the academic year by developing and implementing socio-scientific, context-based, innovative, three-stage modules. The Motivational Learning Environment (MoLE) model and questionnaire was used to measure the impact of context-based science modules on the motivation of sixth to eleventh graders at secondary schools in Georgia. Students' wish- to reality-differences data were analyzed concerning the seven dimensions of the Motivational Learning Environment model. As a result of a one-year training program we observed statistically significant differences in two dimensions for the treatment classes (compared to the control classes) in pre- and post-test results. The study suggests more education systems should consider context-based, socio-scientific science teaching as a leading approach to enhance students' motivation and interest in science education.

Keywords: context-based science teaching, motivational learning environment, socio-scientific issues, student intrinsic motivation

INTRODUCTION

This paper describes a context-based science teaching approach tested in Georgian schools in recent years. Georgia began to build a new educational system after the collapse of the USSR in 1991. There were many attempts to change directive teaching methods, which were dominant in Soviet pedagogy, with student-oriented approaches. The most substantial changes began in 2004 within the National Education Reform (Kapanadze et al., 2015b), which was supported by the Education System Realignment and Strengthening Project (World Bank, 2006). Crucial changes were presented in the first edition of the National Curriculum, which has been in place since 2006. The new curriculum aimed to acknowledge student-oriented teaching and learning as the main pedagogical approach (Kapanadze et al., 2011; Kapanadze & Eilks, 2014). Conceptual changes in the teaching of science were suggested as well. For instance, Math and Physics, on the one hand and Biology and Chemistry on the other hand were considered as different subject/learning areas in the Soviet education system. The first attempt to incorporate the three natural sciences (Biology, Chemistry, and Physics) into one learning area with common inquiry aims and goals took place from 2006 onwards. The new science curriculum was based on an interdisciplinary integration approach (Drake & Burns, 2004), and the integration area was around scientific inquiry. Current science curriculum topics also provided more opportunities for integration between subjects and for making connections to socio-scientific contexts (NCP, 2014). School textbooks approved by the Ministry of Education and Sciences based on the latest version of the National Curriculum were published (MoES, 2016). Schools were equipped with tools for hands-on, science activities. However, both textbooks and school equipment are the subject of intense criticism today (World Bank, 2014). This stems from their lack of relevance to Inquiry-Based Science Education. The government also supported teachers' professional development through delivering centralized training, which agencies of the Ministry of Education and Sciences of Georgia organized. The training was, and

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Contribution to the literature

- The study suggests context-based socio-scientific science teaching may be a leading approach to increasing students' motivation and interest in science education.
- The study suggests that motivational learning environment dimensions are developed step by step and not simultaneously.
- Contextual factors have a positive impact on students' intrinsic motivation.

usually still is, a short-term intervention. It mainly focuses on general pedagogy, and subject content-oriented issues rather than on student-oriented inquiry-based learning, aiming to prepare teachers for qualification examinations (World Bank, 2014).

From 2012, Ilia State University provided long-term training for in-service science teachers under the umbrella of a number of international projects. All teachers had free access to learning materials and training modules, which were developed and implemented, based on cooperation with European universities such as Freie Universität Berlin, University of Bremen, and the University of Limerick. The international project SALiS (2014) specifically developed a curriculum outline for a training course for science educators and science teachers. The course was based on modern educational theories in the field of science education. It prepared in-service and pre-service teachers to teach in a more student-active learning manner (hands-on and minds-on) in science (SALiS, 2014). Another international project at Ilia State University was the PROFILES project (Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science) (2010). It was a European Commission, FP7-funded project in the field of "Science in Society". It promoted IBSE through raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students (Bolte, Streller et al., 2012). The project was based on a long-term teacher-professional development approach aiming for the development of leadership in teachers (Hofstein & Mamlok-Naaman, 2014). Project outcomes were significant, because teachers who are teaching science in a context-based and inquiry-based manner displayed a high level of ownership of initiatives (Hofstein & Mamlok-Naaman, 2014). In the PROFILES project, partners from 21 countries assessed the impact of the project interventions on the motivation of a total of 19,776 students via the teachers involved in the project's CPD programmes (Bolte, 2014). The lesson plans and materials used in the treatment-study reported here reflect the PROFILES project philosophy (Bolte, 2010; Bolte, Streller et al., 2012) and are based on the Motivational Learning Environment (MoLE) model (Bolte, 2006a, 2006b).

THEORETICAL FRAMEWORK

Motivation

Learning is a multidimensional cognitive process that affects and is affected by many factors (Bolte et al., 2013). Motivation and interest are one of the most influential aspects in education. Researchers consider several constructs that predict students learning performance in science classes (Glynn & Koballa, 2006). For the presented study, authors of this paper focused on extrinsic and intrinsic motivation, self-determination, and educational interest, as a pre-attribute for student's motivation.

According to Deci and Rayn (2000) "to be motivated means to be moved to do something". In Self Determination Theory (Ryan & Deci, 1985) motivation is differentiated into two types: extrinsic and intrinsic motivation (Bolte et al., 2013; Koballa & Glynn, 2007). In other words, motivation is driven in some cases by more internal and/or in other cases by more external factors (motives). For instance, one student could be motivated to do homework because of grades or to avoid trouble with the teacher and/or his parents. Others are mainly motivated because of their interests and the feeling of satisfaction in doing and learning science, and by realizing the value of the development of his/her personal capabilities. In both cases, the motivation of students might be high, but the learning actions are based on different orientations (Ryan & Deci, 2000b). Intrinsic motivation is based on learners seeking to explore, to extend capacities, and to be challenged (Ryan & Deci, 2000a). Intrinsic motivation is not a personal characteristic. Rather, it exists in the relation between a person and any particular task or object within a specific situation (Krapp, 2002). Individuals may be motivated by doing some activities, but the same individuals may not be motivated to do other activities. Because there are specific connections between the individual and the task she/he is dealing with, some researchers consider intrinsic motivation in the context of task features. Others deal with it in the context of personal satisfaction and self-determination (Ryan & Deci, 2000b). In the case of extrinsic motivation, the behavior of an individual is not (so much) self-determined, while the behavior is self-determined with intrinsic motivation (Bolte et al., 2013).

Another important predictor of students' performance is his or her interest. The *Educational-Psychological-Theory of Interest* developed by Krapp

(2002) and colleagues presents a conceptual model of interest. Krapp's theory considers two poles of interests: situational interest and individual interests. The situational interest leads to short term motivation, because the motivational stimulus also appears only for a short time. Situational interest may be a starting point for individual interest, but unfortunately, situational interests do not always transform into long-term individual interest (Bolte et al., 2013; Hidi & Renninger, 2006; Stuckey et al., 2013).

Context-based Teaching and Socio-scientific Issue

To increase students' motivation and interest in the sciences, context-based teaching is considered an important teaching approach (Gilbert et al., 2011). There are many interpretations of context-based learning. Duranti and Goodwin (1992) identify four attributes of context-based teaching (*Setting of a focal event; Behavioral environment; Specific language; Extra-situational background knowledge*). Gilbert (2006) defined and adapted those attributes to science education. Testing of different models for context-based course design suggests that context as the social circumstances is more effective than other approaches (Gilbert, 2006; Gilbert et al., 2011) and meets all four attributes of success. Some authors consider context-based science education as a Socio-Scientific Issues (SSI)-based science education (Eilks et al., 2013; Hofstein et al., 2010; Stolz et al., 2013).

The Socio-Scientific Issues-based teaching approach was one of the main focuses for PROFILES consortium partners in the framework of the project. The project partners developed many modules based on the socio-scientific teaching approach (Kennedy & Lucey, 2014; Schindler et al., 2014). All PROFILES teaching and learning materials (modules) were shared among the partners and disseminated via the partners' websites as an open resource. Some of these were used in this treatment-study.

The "PROFILES modules" aim is to raise student's intrinsic motivation through suggesting everyday related scenarios as an extrinsic motivational aspect (Bolte et al., 2014; Bolte, Streller et al., 2012; Devetak et al., 2014; Hartikainen-Ahia et al., 2014). All learning modules "combine the motivational IBSE, a realism approach to science, interrelating the science learning with the real world and the need for an educational thrust as indicated by the education through science conception" (Bolte, Streller et al., 2012, p. 35). These approaches were realized in three-stage modules. The first stage of all modules focused on evoking students' intrinsic motivation and his/her situational interest (Hidi & Renninger, 2006; Krapp, 2002; Prenzel, 1992). At this stage, teachers suggested real-life situations and problems (Bolte, Streller et al., 2012). All modules were based on students' daily lives to encourage intrinsic motivation and with the hope of fostering – in the long-term – interest in science. The modules lead students to understand science concepts by asking inquiry questions. It was also important for teachers to understand that students' questions might differ from teachers' expectations. This stage of the module aimed to encourage students to realize that science lessons were not only about science, but also that they had the opportunity to be involved in science activities. At the second stage, motivational aspects were sustained, and teachers worked on learning outcomes that cover cognitive aspects and inquiry skills. Students were engaged in inquiry activities, working together with their schoolmates, and developing teamwork skills. In this way, students became familiar with the main science concepts and issues of inquiry. Students worked out hypotheses, planned hands-on experiments, and carried them out. In the third stage, teachers and students discussed the findings they discovered. Students provided scientific explanations of the questions that they put forward in the first stage. Students connected findings with the socio-scientific issue which was the motivational starting point within the first stage. Below we present one example of a three-stage module based on the PROFILES philosophy that fits the Georgian context.

RESEARCH QUESTIONS

The research questions posed for this study are:

- Does the three-stage context-based module for teaching of science affect a student's perception of the motivational learning environment in the treatment classes?
- Do gender and contextual factors (school location and school type) affect a student's perception of the motivational learning environment in the treatment classes?

RESEARCH METHODOLOGY

For our research we used a quasi-experimental model with nonequivalent groups design (Cook & Campbell, 1979). The questionnaire for the Assessment of the Motivational Learning Environment (MoLE) developed by Bolte (2006b, 2010) was used for this study. The questionnaire provides information about students' perceptions of their science classes before and after the intervention. The survey instrument is a self-administered paper-and-pencil-questionnaire. The original questionnaire was developed in German. For the current study the questionnaire was translated into Georgian, and the authors validated the instrument.

Intervention and Module Development

During the PROFILES project, 21 in-service teachers had at least 40 hours of face-to-face training and/or online communication (Kapanadze et al., 2015a). The teachers cooperated within the project for one year,

Table 1. Distribution of students by gender, school type, school location for treatment and control cases

Students	Treatment	Control	Total
Gender			
Boys	184	139	323
Girls	194	187	381
School type			
Private school	164	123	287
Public school	214	203	417
School location			
Rural school	115	106	221
Urban school	263	220	483

Note. N = 704

participated in meetings, training, online communication, and consultations. They worked on adopting and/or development of context-based three-stage science modules. Context-based modules were implemented into classes after the training and meetings. For the intervention, 10 different modules were selected. The length of each module was 3-4 lesson hours.

In this study, we used three-stage context-based modules PROFILES partners developed (PROFILES, 2010). One of the modules focused on the question of what type of soft drink should be chosen (Streller et al., 2011). This module was created in the framework of another EU project (SALiS, 2014). The modules used in Georgia were translated into the native language and adapted to meet the needs and regulations in Georgian schools.

The Georgian project team members created several new modules as well (Kapanadze & Slovinsky, 2014a, 2014b). All modules were three-staged and based on the PROFILES philosophy (Bolte, Streller et al., 2012). The modules had a motivational title like "Cheese Making: Which to Use – Modern Technology or Nature's Way?" created by biology teacher Bagatrishvil (Kapanadze & Slovinsky, 2014b). The learning process started with an everyday context-based scenario. For instance, this module's starting story was based on a real issue following a student visit to her grandmother in a village. She saw a flask with very interesting material in it – the abomasum of calve placed into whey, together with some salt and vinegar, beans, wheat, and corn seeds. Students were told that this material was how cheese-making takes place naturally, and they decided to investigate cheese production technology (Kapanadze & Slovinsky, 2014b). In the second stage of the module, teachers undertook classroom discussions, and students had to think about the science concepts and to pose scientific questions like, "What are the factors affecting the production of cheese starting from milk?" (Kapanadze & Slovinsky, 2014b). Students planned hands-on experiments to find the effect of different factors (temperature, quality of milk, and types of enzymes) on the cheese-making process. In the third stage, teachers and students summarized their findings, supported discussions, and went back to the original socio-scientific issues. All the implemented modules had the above-described structure.

Sample and Data Collection

The data were collected from the PROFILES project Georgian participants during one academic year. Information about the project was shared via different media sources. Volunteer teachers were interviewed and 21 teachers from 19 schools from different regions in Georgia were selected. Overall, eight biology teachers, seven chemistry teachers, and six physics teachers participated in the study. There were 7 schools from rural regions and 12 from urban regions of Georgia. There were 11 public and 8 private schools. Students involved in this study were from lower and upper secondary classes. In one school, students were in the 6^{th} grade (primary).

Control classes involved in this study were from the same schools and the same grades as the project classes, but the teachers in the control classes did not participate in the project training program.

The number of the participant teachers was determined in the project proposal. The number of the students was determined by the class sizes. The total sample for the study was 1063 students (treatment class students N = 566, control class students N = 497). For further analysis, we used data from students that responded to both (pre-post) questionnaires, as some students responded only to the pre or post questionnaire. The achieved sample size was 704 (treatment class students N = 378, control class students N = 326) (Table 1).

Questionnaire Design

Combining the *Educational-Psychological-Theory of Interest* (Prenzel, 1992; Krapp, 2002) and the *Self Determination Theory of Motivation* (Ryan & Deci, 2000a), Bolte (2004) developed a theoretical model which describes the effects of different variables on the Motivational Learning Environment (MoLE) in a science classroom. He created the MoLE model consisting of seven different dimensions (variables), which were shown as statistically sound and pedagogically useful to analyze the motivational learning environment in

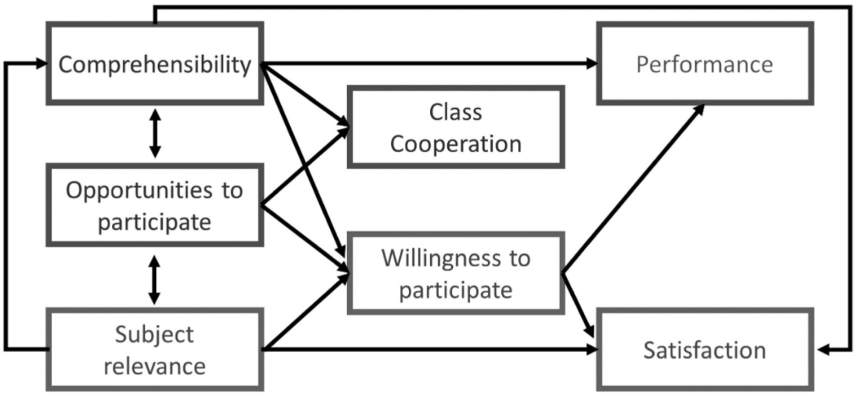

Figure 1. The model of motivational learning environment
Note. Developed by Bolte (2006b)

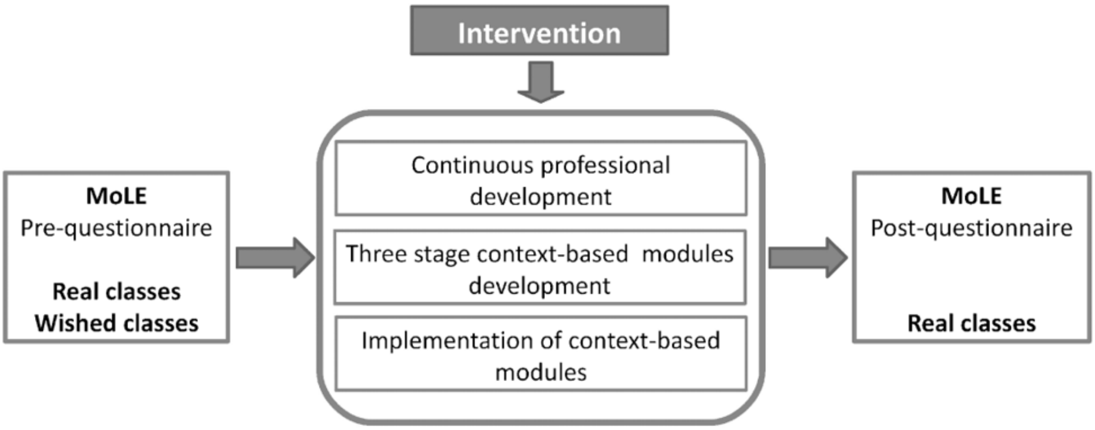

Figure 2. Data collection flowchart

science classes and to predict students' learning outcomes. The dimensions are termed as follows:

- Student satisfaction;
- Comprehensibility
- Subject relevance;
- Opportunities to participate;
- Class cooperation;
- Student's willingness to participate; and finally
- Student's performance.

Statistical analysis validated the theoretically based connections between the MoLE variables (Bolte, 2006a; Bolte & Streller, 2012b, 2012c; Bolte et al., 2013). The interdependence of construct's variables is presented in Figure 1.

Three variables (comprehensibility, opportunities to participate and subject relevance, which is differentiated into the two sub-scales: relevance of the topic and subject orientation) correspond to the teacher's behavior and are very much influenced by his/her lesson planning. Four variables (class cooperation, individual student's willingness to participate, his/her satisfaction and his/her learning outcomes (performance)) are reliant upon the class in general and the individual student (Bolte, 2001, 2012; Bolte et al., 2013).

The MoLE questionnaire allows a systematic analysis of students' sense of ongoing and desired science classes. The questionnaire collects information not only about real classes but also about wished-for classes. This approach assesses how real classes met the students' desired learning environment (Bolte & Streller, 2012a; Bolte et al., 2013).

During the study, students were asked to answer three different questionnaires. Before intervention (within the pre-test), the students filled in the items of the pre-questionnaire assessing "real classes" and a specific pre-questionnaire version focusing on how the students wished science classes were (so-called "wished classes"). After the intervention, the students answered the post-questionnaire. Again, this was to assess their perceptions of the actual classes. The treatment group students were supposed to focus on and to assess the treatment lessons, while the control group students were asked to focus on the last four lessons they experienced. The flowchart in Figure 2 presents the data collection process.

Each questionnaire (real-pre, wished-pre, and real-post) consists of fourteen items. Each item is an ordinal variable and measured on a seven-pointed Likert scale. Students were asked to express their opinions about each item's content by means of a seven-point-rating-scale (see Figure 3). The high numerical values from 5-7 correspond to positive statements. Numerical values from 1-3 are given to statements that have negative

Item No. 2 in the real classes pre-questionnaire
In my chemistry class I feel...
very comfortable □ □ □ □ □ □ □ *very uncomfortable.*

Item No. 2 in the wished classes pre-questionnaire
To me it is...
very important □ □ □ □ □ □ □ *completely unimportant...*
that I am comfortable in chemistry lessons.

Item No. 2 in the real classes post-questionnaire
In my today chemistry class, I feel...
very comfortable □ □ □ □ □ □ □ *very uncomfortable.*

Figure 3. The modifications of the Item in the Pre-real, Pre-wished, and Post-real questionnaire
Note. Examples of Items for the Same Variable (Comfort) from the Three Versions of the MoLE-questionnaire (Bolte, 2006a, 2006b)

Table 2. Item descriptions and their connection to a variable

No. of items	Items	Variables/Dimensions
Q1	Joy	Satisfaction
Q2	Comfort	
Q3	Comprehension	Comprehensibility
Q4	Time for reflection	
Q5	Formula	Subject orientation
Q6	Matter	
Q7	Everyday life	Relevance of the topics
Q8	Society	
Q9	Proposition	Students' opportunities to participate
Q10	Asking questions	
Q11	Class cooperation	Class cooperation
Q12	Class effort	
Q13	Individual student's effort	Individual student's willingness to participate
Q14	Individual student's attendance	

interpretations of science lessons, and the value 4 is given as a neutral assessment, e.g., a neither/nor (Bolte, 2006b; Bolte et al., 2013; Bolte & Schneider, 2014).

Each item in all three questionnaires (real-pre, wished-pre and real-post) measures the same aspects but have somewhat different wordings. Figure 3 gives an example of how the items are modified in real-pre, wished-pre, and real-post questionnaires.

Fourteen items measure seven variables (dimensions) of the motivational learning environment. Each variable is constructed from the two items that measure a specific aspect of the MoLE-dimension. For instance, item 1 is about joy and item 2 is about personal comfort in science lessons. Both items describe dimension 'satisfaction' of the motivational environment from the students' personal viewpoint. In Table 2, all item labels and their relationship to the seven variables/dimensions are provided. All further analysis in this study is based on the seven MoLE dimensions.

Validation

The original MoLE questionnaire was created and tested in several studies in Germany (Bolte, 1996, 2006a, Bolte & Schulte, 2014; Bolte & Streller, 2012a, 2012c). The original version was analyzed using factor analysis (Bolte, 1996, 2006b). These analyses show a strong construct validity for the variables making up the MoLE-model (Bolte, 2006a). Internal consistency (Cronbach's alpha coefficient) for the original instrument's variables varies between 0.59 and 0.82 (Stuckey & Eilks, 2014).

For the current research, the MoLE questionnaire was translated into Georgian language, and the translated version (MoLE-Ge) of the instrument was validated. The validation of the MoLE-Ge questionnaire was done during the first round of PROFILES project implementation in Georgia, and the sample size was N=739. This was one year before the start of the study presented in this article. For this purpose, content, and construct validation measures were used (Tuan et al., 2005).

Table 3. Factor loading of items for instrument validation in MoLE-GE translated questionnaire

Item	Factor Loading						
	1	2	3	4	5	6	7
Factor 1: Satisfaction							
Q2 - Comfort	**.86**						
Q1- Joy	**.80**						
Factor 2: Individual student's willingness to participate							
Q13 - Student's-effort		**.84**					
Q14 - Student's-attendance		**.78**					
Factor 3: Relevance of the topics							
Q8 - Society			**.87**				
Q7 - Everyday life			**.79**				
Factor 4: Subject orientation							
Q6 - Matter				**.87**			
Q5 - Formula				**.86**			
Factor 5: Class cooperation							
Q11- Class-cooperation					**.87**		
Q12 - Class-effort					**.77**		
Factor 6: Students' opportunities to participate							
Q10 - Asking questions						**.88**	
Q9 - Proposition						**.75**	
Factor 7: Comprehensibility							
Q4 - Time							**.88**
Q3 -Comprehension							**.65**

Note. *N* =739. All loadings smaller than 0.6 have been excluded

Table 4. Internal consistency for instrument validation in MoLE-Ge

Constructs	Cronbach's α	No. of items
Satisfaction	.83	2
Comprehensibility	.56	2
Subject orientation	.72	2
Relevance of the topics	.73	2
Students' opportunities to participate	.63	2
Class cooperation	.65	2
Individual student's willingness to participate	.73	2

Note. *N* = 739.

The Georgian PROFILES project team members carried out content validation. Based on the recommendations of subject education experts, some items were edited to improve the wording. Construct validity was tested using factor analysis. Exploratory factor analysis was conducted. Varimax rotation converged in six iterations. All loadings smaller than 0.6 have been excluded. The loading of items for instrument validation in the MoLE-Ge questionnaire shows the strong validity of constructs for the instrument (Table 3).

The internal consistency of the seven variables was checked, and Cronbach's alpha was between 0.56 and 0.83. Cronbach's alpha for the MoLE-Ge questionnaire is presented in Table 4.

Based on the above results, the translated instrument (MoLE-Ge) was validated and is congruent with the theoretical model of MoLE. Therefore, it is possible to use it to answer the research questions.

Data Analysis

For data analysis, inferential statistics were conducted. The questionnaire items which include negative statements were reverse coded. The variables' means were counted for real-pre, wished-pre, and real-post tests. Students' wish-to-reality-differences for seven constructs of the motivational learning environment were analyzed. A paired-samples t-test was used to determine whether there was a statistically significant mean difference between:

a) the students' wished-scores (in the pre-test) vs. the students' real-scores (in the pre-test) data collection and
b) the students' wished-scores (in the pre-test) vs. the students' real-scores (in the post-test) data collection.

To compare motivational aspects, mean changes between boys and girls, public and private school groups of treatment classes and, control and treatment groups difference of differences were calculated and compered by independent t-test.

RESULTS

Based on students' answers on the fourteen items of each questionnaire-version, means were calculated for

Table 5. Dimension's means for Real (pre), Wished (pre) and Real (post) questionnaire stated by treatment and control classes

Dimensions	Treatment classes		Control classes	
	M	*SD*	*M*	*SD*
Satisfaction				
Real (pre)	5.51	1.29	5.19	1.52
Wished (pre)	6.34	1.05	6.25	1.18
Real (post)	5.94	1.18	5.30	1.57
Comprehensibility				
Real (pre)	5.87	1.15	5.56	1.33
Wished (pre)	6.48	0.86	6.45	0.99
Real (post)	6.05	1.01	5.57	1.41
Subject orientation				
Real (pre)	6.21	1.07	6.07	1.27
Wished (pre)	5.99	1.21	5.94	1.23
Real (post)	6.17	0.99	5.89	1.40
Relevance of the topics				
Real (pre)	5.46	1.50	5.13	1.67
Wished (pre)	5.83	1.30	5.71	1.43
Real (post)	5.61	1.48	5.10	1.76
Students' opportunities to participate				
Real (pre)	6.26	0.88	6.01	1.14
Wished (pre)	6.38	0.89	6.27	1.02
Real (post)	6.26	0.94	5.87	1.33
Class cooperation				
Real (pre)	5.62	1.17	5.16	1.31
Wished (pre)	6.46	0.95	6.21	1.18
Real (post)	5.85	1.13	5.09	1.40
Individual student's willingness to participate				
Real (pre)	6.03	1.16	5.84	1.31
Wished (pre)	6.45	0.97	6.34	1.15
Real (post)	6.07	1.12	5.74	1.41

Note. Treatment classes N= 378, Control classes N=326

each of the seven variables. Furthermore, treatment and control group means are calculated (Table 5).

Students' Wish-to-reality Differences Before the Intervention

As mentioned above, it is not only important to know how students assess their science classes, but also to understand how students see their wished-for classes (Bolte et al., 2013). Analyzing the differences between wished and real classes for the pre-intervention period shows that there were statistically significant differences for all seven variables in the treatment classes and six statistically significant differences in the control cases. Only subject orientation does not show any statistically significant differences (Table 6).

The largest mean difference for the treatment classes was for class cooperation variable ($M = 0.84$, $SD = 1.14$, $p < 0.001$). This was followed by satisfaction ($M = 0.83$, $SD = 1.39$, $p < 0.001$); comprehensibility ($M = 0.62$, $SD = 1.21$, $p < 0.001$); individual student's willingness to participate ($M = 0.42$, $SD = 1.13$, $p < 0.001$); relevance of the topics ($M = 0.37$, $SD = 1.34$, $p < 0.001$); subject orientation ($M = -0.22$, $SD = 1.45$, $p < 0.01$); and students' opportunities to participate ($M = 0.12$, $SD = 1.09$, $p < 0.05$).

Based on the above results, we can see that students wish to improve class environmental dimensions by increasing the possibilities for six of the dimensions and by decreasing only the content oriented component. This indicates that students want less subject-oriented lessons, and that their real lessons are overly subject-oriented.

The same tendencies were observed in control classes. In this case, only the mean difference between wished for and real classes for the variable subject orientation was not statistically significant (Table 6).

Students' Real-post to Real-pre Differences

We've also looked at mean differences between real and post real classes (Table 6).

For the treatment classes, four variables show statistically significant changes. The largest difference is for satisfaction ($M = 0.44$, $SD = 1.12$, $p < 0.001$). Next variables are class cooperation ($M = 0.23$, $SD = 1.21$, $p < 0.001$) and comprehensibility ($M = 0.18$, $SD = 1.10$, $p < 0.01$) followed by relevance of the topics ($M = 0.15$, $SD = 1.23$, $p < 0.05$). For subject orientation, students' opportunities to participate, and individual student's willingness to participate there were no statistically significant differences for the real-pre and -post classes.

Table 6. Dimensions' mean changes for Real (pre), Wished (pre), and Real (post) questionnaire stated by treatment and control classes

Dimensions	*N*	*M*	*SD*	*t*	*p*
Treatment classes					
Satisfaction					
D(W-R)	378	.83	1.39	11.56	.000
D(W-Rp)	378	.39	1.29	5.89	.000
D(Rp-R)	378	.44	1.12	7.55	.000
Comprehensibility					
D(W-R)	378	.62	1.21	9.86	.000
D(W-Rp)	378	.43	1.11	7.57	.000
D(Rp-R)	378	.18	1.10	3.24	.001
Subject orientation					
D(W-R)	378	-.22	1.45	-2.90	.004
D(W-Rp)	378	-.18	1.40	-2.49	.013
D(Rp-R)	378	-.04	1.19	-0.63	.530
Relevance of the topics					
D(W-R)	378	.37	1.34	5.44	.000
D(W-Rp)	378	.22	1.40	3.07	.002
D(Rp-R)	378	.15	1.23	2.42	.016
Students' opportunities to participate					
D(W-R)	378	.12	1.09	2.20	.028
D(W-Rp)	378	.12	1.13	2.07	.039
D(Rp-R)	378	.65	1.45	8.68	.000
Class cooperation					
D(W-R)	378	.84	1.14	14.22	.000
D(W-Rp)	378	.60	1.34	8.77	.000
D(Rp-R)	378	-.23	1.21	-3.74	.000
Individual student's willingness to participate					
D(W-R)	378	.42	1.13	7.27	.000
D(W-Rp)	378	.38	1.19	6.15	.000
D(Rp-R)	378	-.04	0.99	-0.88	.379
Control classes					
Satisfaction					
D(W-R)	326	1.06	1.57	12.23	.000
D(W-Rp)	326	.95	1.66	10.31	.000
D(Rp-R)	326	.12	1.34	1.57	.118
Comprehensibility					
D(W-R)	326	.89	1.35	11.92	.000
D(W-Rp)	326	.88	1.43	11.13	.000
D(Rp-R)	326	.01	1.53	0.13	.899
Subject orientation					
D(W-R)	326	-.13	1.45	-1.64	.102
D(W-Rp)	326	.05	1.64	.56	.577
D(Rp-R)	326	-.18	1.46	-2.25	.025
Relevance of the topics					
D(W-R)	326	.58	1.66	6.26	.000
D(W-Rp)	326	.60	1.88	5.80	.000
D(Rp-R)	326	-.03	1.45	-0.34	.732
Students' opportunities to participate					
D(W-R)	326	.26	1.23	3.80	.000
D(W-Rp)	326	.40	1.53	4.72	.000
D(Rp-R)	326	.91	1.83	8.98	.000
Class cooperation					
D(W-R)	326	1.04	1.54	12.28	.000
D(W-Rp)	326	1.12	1.69	11.94	.000
D(Rp-R)	326	.07	1.46	0.91	.363
Individual student's willingness to participate					
D(W-R)	326	.49	1.36	6.54	.000
D(W-Rp)	326	.60	1.49	7.23	.000
D(Rp-R)	326	.10	1.15	1.61	.109

Note. D(W-R): Real-pre test scores are subtracted from Wished test scores. D(W-Rp): Real-post test scores are subtracted from Wished test scores. D(Rp-R): Real-pre test scores are subtracted from real-post test scores.

Table 7. Difference-in-differences stated by treatment and control classes

Dimensions	N	M	SD	t	p
Treatment classes					
Satisfaction	378	.44	1.12	7.55	.000
Comprehensibility	378	.18	1.10	3.24	.001
Subject orientation	378	-.04	1.19	-.63	.530
Relevance of the topics	378	.15	1.23	2.42	.016
Students' opportunities to participate	378	.00	.99	.05	.959
Class cooperation	378	.23	1.21	3.74	.000
Individual student's willingness to participate	378	.04	.99	.88	.379
Control classes					
Satisfaction	326	.12	1.34	1.57	.118
Comprehensibility	326	.01	1.53	.13	.899
Subject orientation	326	-.18	1.46	-2.25	.025
Relevance of the topics	326	-.03	1.45	-.34	.732
Students' opportunities to participate	326	-.14	1.33	-1.91	.056
Class cooperation	326	-.07	1.46	-.91	.363
Individual student's willingness to participate	326	-.10	1.15	-1.61	.109

Note. Post-test differences are subtracted from pre-test differences; Independent samples t-test was used.

For the control classes, there was only one statistically significant change for subject orientation (M = -0.18, SD = 1.46, p < 0.05). This suggests that lessons became less subject-oriented in comparison with the students' assessment in the beginning of the school year.

Students' Wish-to-reality Differences After the Intervention

After-intervention data were analyzed focusing on the wish-to-reality-differences (Table 6). For treatment classes, there were still statistically significant differences between wished for and real classes for all seven variables. The largest differences were observed for class cooperation (M = 0.60, SD = 1.34, p < 0.001) and comprehensibility (M = 0.43, SD = 1.11, p < 0.001). Next is satisfaction (M = 0.39, SD = 1.29, p < 0.001) and individual student's willingness to participate (M = 0.38, SD = 1.19, p < 0.001). For all seven variables, the means of differences decreased in comparison with prior to the intervention. This means that after the intervention, science lessons became more relevant to students.

For control classes, there were also statistically significant differences, with the exception of the variable subject orientation. For two variables (satisfaction and comprehensibility), there was a positive change. Regarding the variables relevance of the topics, students' opportunities to participate, class cooperation, and individual student's willingness to participate, the data showed that motivational aspects of the learning environment declined for the control group students during the academic year.

To test for statistical significance, we calculated difference-in-differences for each dimension (Table 7). In this regard we subtracted from the difference of wished and pre-real data the difference of wished and post-real data.

We can see that after the intervention the most notable result is for satisfaction (M = 0.44, SD = 1.12, p < 0.001), for class cooperation (M = 0.23, SD = 1.21, p < 0.001), comprehensibility (M = 0.18, SD = 1.10, p < 0.01) and relevance of the topics (M = 1.5, SD = 1.23, p < 0.05).

Comparison of Treatment and Control Groups

In regard to the effect of the intervention, we compared treatment and control classes and found out that differences were statistically significant only for two dimensions: satisfaction (t (637) = 3.40, p < 0.001) and class cooperation (t (633) = 3.00, p < 0.5) (Table 8).

As we have mentioned above, only two dimensions show positive changes in treatment classes. These variables are analyzed controlling for gender, school location, and school type. The data shows (Table 9) that urban schools' students are more satisfied then their classmates from rural schools (t (376) = - 2.52, p < 0.05). We find that there are statistically slight significant differences for class cooperation (t (376) = 3.11, p < 0.01) between private and public schools. Private schools' students were more positive in their perceptions. They liked the changes in the class cooperation and how schoolmates made an effort together during the science lessons. They scored higher than public school students. No statistically significant differences are observed by gender.

Limitations

The study has several limitations. First of all, the treatment and control class teachers are different persons. The treatment classes' teachers were project members. The selection of those teachers was not random. Most were proactive. They found information about the project via the Internet and sent letters of interest to us by email. These teachers have better access to and skills in ICT. We assume that teachers involved in the PROFILES teacher-training program were more motivated in general than the control group teachers.

Table 8. Comparison of treatment and control classes per dimensions

Dimensions	*N*	*M*	*SD*	*t*	*df*	*p*
Satisfaction						
Treatment classes	378	.44	1.12	3.40	637	.001
Control classes	326	.12	1.34			
Comprehensibility						
Treatment classes	378	.18	1.10	1.70	581	.090
Control classes	326	.01	1.53			
Subject orientation						
Treatment classes	378	-.04	1.19	1.42	625	.156
Control classes	326	-.18	1.46			
Relevance of the topics						
Treatment classes	378	.15	1.23	1.77	641	.078
Control classes	326	-.03	1.45			
Students' opportunities to participate						
Treatment classes	378	.00	0.99	1.61	592	.109
Control classes	326	-.14	1.33			
Class cooperation						
Treatment classes	378	.23	1.21	3.00	633	.003
Control classes	326	-.07	1.46			
Individual student's willingness to participate						
Treatment classes	378	.04	0.99	1.83	702	.068
Control classes	326	-.10	1.15			

Note. Independent Samples t-test is used for analysis

Table 9. Comparison of gender, school location and school type groups

Dimensions	*N*	*M*	*SD*	*t*	*df*	*p*
Gender						
Satisfaction						
boy	184	.326	1.17	-1.87	376	.063
girl	194	.541	1.07			
Class cooperation						
boy	184	.280	1.15	.737	376	.462
girl	194	.188	1.27			
Class Type						
Satisfaction						
Private	164	.48	1.21	.59	376	.555
Public	214	.41	1.06			
Class cooperation						
Private	164	.45	1.23	3.11	376	.002
Public	214	.07	1.17			
School location						
Satisfaction						
Rural	164	.22	1.07	-2.52	376	.012
Urban	214	.53	1.14			
Class cooperation						
Rural	164	.08	0.98	-.60	376	.549
Urban	214	.30	1.29			

Note. Independent Samples T-test is used for analysis

The other limitation stems from the general context of the education system in Georgia. It was implied that there were no other external factors (other professional development activities for teachers, which influence their teaching methods; student's seminars, etc.) influencing the student's perceptions or teachers' teaching methods throughout the project. The project teachers were not involved in any other training programs.

DISCUSSION

The results of our research demonstrate that context-based, socio-scientific science teaching should be considered as a leading approach to enhance students' motivation and interest in science. Earlier studies indicate that educators try to change the content and pedagogy of science education and make it more meaningful, relevant, and contextualized. (Eilks, Marks & Feierabend, 2008; Gilbert, 2006; Hofstein & Kesner, 2006). But here arises a question: What makes a context a "good context"? Which characteristic of context might be termed 'good context' for promoting scientific literacy? (Hofstein et al., 2010, p. 10). Some studies discussed the issue of the relevance of science education and encouraged more links to society (Sadler & Zeidler, 2009; Zeidler et al., 2005).

As we state in our study, after the intervention, a one-year collaboration with in-service science teachers and the implementation of one or two context-based modules (3-5 lessons), there are statistically significant positive changes for all seven dimensions, but differences between wished and real classes after the intervention still exist. The intervention increased motivational aspects only for two dimensions (satisfaction and class cooperation). Both of them are reliant upon the class in general and the individual student (Bolte, 2012; Bolte et al., 2013). Cooperative learning is also discussed as an item related to relevance in science education by Hofstein et al. (2010). Relevance was linked to students' satisfaction and personal closeness of the subject as a part of motivation by Holbrook and Rannikmäe (2009).

The increased motivational dimensions in treatment classes for our study are just a starting point and might be considered as a situational interest. How to transform this into individual interest and to sustain students' intrinsic motivation through concept-based teaching is an issue requiring further research. Motivational aspects are the subject of many studies because they are relevant to current debates (Krapp & Prenzel, 2011; Sjøberg & Schreiner, 2010; Wood, 2019).

As we state from the results of this research, relatedness and emotional aspects are the two domains that are most affected by the intervention. No aspect that corresponds to the teacher's behavior appeared. These results suggest that one-year professional development for the teachers is not enough to increase or sustain students' long-term interest in science and science learning. It is recommended well-structured, long-term professional development courses for science teachers (Dori & Herscovitz, 2005).

For further discussion, the presented study results are compared with the OECD Programme for International Student Assessment 2015 results (OECD, 2016). PISA 2015 also looked at students' attitudes towards science and economics in 72 countries. Regarding the PISA reports (OECD, 2016), motivational aspects are significant predictors of student performance. The same is true for Georgian students. For instance, an increase in the science enjoyment index is associated with a 23-point increase in science test results. On PISA in Georgia, girls have higher intrinsic motivation than boys toward science. Georgia is one of 18 countries where girls are more motivated in science learning than boys (NAEC, 2017; OECD, 2016). This tendency is not present in our study. The gender differences do not exist. This suggests that the three stage context-based modules might be relevant for girls as well as for boys. According to the PISA national report (NAEC, 2017), the effect of private schools is statistically significant. Georgian students from private schools score higher on the index of enjoyment than students from public schools. This study shows the same tendency. More motivational improvement in class cooperation is observed in private schools than in public schools. Private schools have better opportunities in terms of facilities and freedom for the transformation of the school curriculum. Better facilities also may explain the increased satisfaction scores after the intervention in urban schools compared with rural schools. In PISA, there are no statistically significant differences in motivational aspects by school location (rural, urban).

CONCLUSION

This study suggests that context-based socio-scientific science teaching after a one-year implementation, effects some of the seven dimensions of the motivational learning environment. Specifically, it increases satisfaction and class cooperation. We think that for a sustained effect, one or two modules of implementation during one-year teacher professional development courses are insufficient to increase student intrinsic motivation. For more sustainable effects, the teacher professional development process should be longer and students' needs should be identified before teacher trainings. In this regard, inquiry-based science lessons with a focus on student needs and interests should become the rule, rather than an exception.

The PROFILES project and this study has validated the MoLE instrument for further research on student motivation to learn science in Georgia. This will enable future research and Georgia's inclusion in international studies. Some joint studies with the other countries are possible and desirable, as the MoLE instrument is already translated into 17 different languages (e.g., Czech, Danish, English, Estonian, Finnish, Georgian, German, Greek, Hebrew, Italian, Latvian, Polish, Portuguese, Romanian, Spanish, Swedish and/or Turkish (see PROFILES, 2014 for more detail)).

The findings of this study about the context-based socio-scientific science teaching could be useful for science educators for their further actions, but especially for post-soviet countries, which are still struggling against the effects of the more teacher oriented education which was dominant in the, centralized Soviet school system. As teachers are the key actors for successful implementation of most education reforms, teacher professional development courses are very important for better results in education.

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