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

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Received 30 January 2021 • Accepted 29 June 2021

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
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,
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 6th 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

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**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*
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
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).

| No. of items | Items                      | Variables/Dimensions                      |
|--------------|----------------------------|-------------------------------------------|
| Q1           | Joy                        | Satisfaction                              |
| Q2           | Comfort                    | **Comprehensibility**                     |
| Q3           | Comprehension              | **Subject orientation**                   |
| Q4           | Time for reflection        | Relevance of the topics                   |
| Q5           | Formula                    | Students’ opportunities to participate    |
| Q6           | Matter                     | Class cooperation                         |
| Q7           | Everyday life              | Individual student’s willingness to participate |
| Q8           | Society                    | Individual student’s attendance           |
| Q9           | Proposition                |                                           |
| Q10          | Asking questions           |                                           |
| Q11          | Class cooperation          |                                           |
| Q12          | Class effort               |                                           |
| Q13          | Individual student’s effort|                                           |
| Q14          | Individual student’s attendance|                                             |
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 compared by independent t-test.

**RESULTS**

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

| Table 3. Factor loading of items for instrument validation in MoLE-GE translated questionnaire |
|---------------------------------------------------------------|
| Item | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 |
| QA- Comfort | .86 | | | | | | |
| Q1- Joy | .80 | | | | | | |
| Q13- Student’s-effort | .84 | | | | | | |
| Q14- Student’s-attendance | .78 | | | | | | |
| Q8- Society | .87 | | | | | | |
| Q7- Everyday life | .79 | | | | | | |
| Q6- Matter | .87 | | | | | | |
| Q5- Formula | .86 | | | | | | |
| Q11- Class-cooperation | .87 | | | | | | |
| Q12- Class-effort | .77 | | | | | | |
| Q10- Asking questions | | | | | | | |
| Q9- Proposition | | | | | | | |
| Q4- Time | | | | | | | |
| Q3-Comprehension | | | | | | | |

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.
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.

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

| Dimensions                                      | Treatment classes | Control classes |
|------------------------------------------------|-------------------|-----------------|
|                                                | N | M  | SD | t       | p       | N | M  | SD | t       | p       |
| 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 | -.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 | -.88  | .379    |   |    |    |        |         |
|                                                |   |    |    |        |         |   |    |    |        |         |
| Note. D(W-R): Real-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.
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.
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

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**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| 1.70| 581 | .090 |
| Comprehensibility               |    |     |     |     |     |      |
| Treatment classes               | 378| .18 | 1.10| 1.42| 625 | .156 |
| Control classes                 | 326| .01 | 1.53| 1.77| 641 | .078 |
| Subject orientation             |    |     |     |     |     |      |
| Treatment classes               | 378| -.04| 1.19| 1.46| 625 | .156 |
| Control classes                 | 326| -.18| 1.46| 1.77| 641 | .078 |
| Relevance of the topics         |    |     |     |     |     |      |
| Treatment classes               | 378| .15 | 1.23| 1.77| 641 | .078 |
| Control classes                 | 326| -.03| 1.45| 1.77| 641 | .078 |
| Students’ opportunities to participate | | | | | | |
| Treatment classes               | 378| .00 | 0.99| 1.61| 592 | .109 |
| Control classes                 | 326| -.14| 1.33| 1.61| 592 | .109 |
| Class cooperation               |    |     |     |     |     |      |
| Treatment classes               | 378| .23 | 1.21| 3.00| 633 | .003 |
| Control classes                 | 326| -.07| 1.46| 3.00| 633 | .003 |
| Individual student’s willingness to participate | | | | | | |
| Treatment classes               | 378| .04 | 0.99| 1.83| 702 | .068 |
| Control classes                 | 326| -.10| 1.15| 1.83| 702 | .068 |

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

**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.
intrinsic motivation through concept-based teaching is be considered as a situational interest. How to transform an issue requiring further research. Motivational aspects are the subject of many studies because they are relevant to current debates (Krapp & Prenzel, 2011; Sjøberg & 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 (Krap & 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.

**Author contributions:** All authors have sufficiently contributed to the study, and agreed with the results and conclusions.

**Funding:** This study was funded within the SEVENTH FRAMEWORK PROGRAMME (5.2.2.1 SiS-2010-2.2.1) of the European Commission: Supporting and coordinating actions on
innovative methods in science education: teacher training on inquiry-based teaching methods on a large scale in Europe (Grant agreement no.: 266589).

Acknowledgements: The authors are thankful to the students, teachers, and school principals that participated in the study as well as to Freie Universität Berlin and Ilia State University PROFILES teams’ members for their cooperation within this study. We would also like to express our thanks to the colleagues of the PROFILES Consortium.

Declaration of interest: No conflict of interest is declared by authors.

REFERENCES

Bolte, C. (1996). Aspects of science instruction in the view of German junior high school students - Conception and application of the computer-assisted procedure for the analysis of motivational learning climate issues in biology, chemistry and physics instruction. Proceedings of the Annual Meeting of the National Association for Research in Science Teaching (NARST), USA. (Polyscript).

Bolte, C. (2001). How to enhance students’ motivation and ability to communicate in science class-discourse. In H. Behrendt, H. Dahmcke, R. Duit, W. Gräber, M. Komorek, A. Kross, & P. Reiska (Eds.), Research in Science Education - Past, Present, and Future (pp. 277-282). Springer. https://doi.org/10.1007/0-306-47639-8_38

Bolte, C. (2004). Motivationale Lernklima im Chemieunterricht [Motivational learning climate in chemistry classes]. Praxis der Naturwissenschaften Chemie in der Schule, 53(7), 33.

Bolte, C. (2006a). As good as it gets: The MoLE-instrument for the evaluation of science instruction. Proceedings of the Annual Meeting of the National Association for the Research on Science Education (NARST), USA.

Bolte, C. (2006b). Evaluating science instruction by using the motivational learning environment questionnaire. Proceedings of the annual meeting of the American Educational Research Association (AERA), USA.

Bolte, C. (2010). Contemporary scientific literacy and the (ir-)relevance of science education. In I. Eilks & B. Ralle (Eds.), Contemporary scientific education – Implications from science education research for orientation, strategies and assessment (pp. 23-34). Shaker.

Bolte, C. (2012). How to analyse and assess students’ motivation to learn chemistry. In M. Kapanadze, & I. Eilks (Eds.), Student Active Learning in science (pp. 85-91). Ilia State University Press.

Bolte, C. (2014). Evaluating students gains in PROFILES. In C. Bolte, & F. Rauch (Eds.), Enhancing inquiry-based science education and teachers’ continuous professional development in Europe: Insights and reflections on the PROFILES Project and other projects funded by the European Commission (pp. 48-51). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/3onnFFL

Bolte, C., & Schneider, V. (2014). Chemistry in Projects (ChiP) - An evidence-based continuous professional development programme and its evaluation regarding teacher ownership and students gains. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), Science teachers’ continuous professional development in Europe: Case studies from the PROFILES Project (pp. 220-230). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/3ooCmwf

Bolte, C., & Schulte, T. (2014). Stakeholders’ Views on Empirically based Concepts for Science Education to Enhance Scientific Literacy - Results from the Third Round of the International PROFILES Curricular Delphi Study on Science Education. In C. P. Constantinoou, N. Papadouris, & A. Hadjigeorgiou (Eds.), E-Book Proceedings of the ESERA 2013 Conference: Science Education Research for Evidence-based Teaching and Coherence in Learning. Part 8 (co-ed. M. Ossevoort & J. A. Nielsen) (pp. 197-204). European Science Education Research Association.

Bolte, C., & Streller, S. (2012a). Evaluating students active learning in science courses. Chemistry in action! (97), 13-17. https://bit.ly/3vOVlE9

Bolte, C., & Streller, S. (2012b). A longitudinal study on science interests. In C. Bruguière, A. Tiberghien & P. Clément (Eds.), E-book proceedings of the ESERA 2011 Conference: Science learning and citizenship. Part 10 (co-ed. R. Millar), (pp. 73-79). European Science Education Research Association.

Bolte, C., & Streller, S. (2012c). Evaluating student gains in the PROFILES Project. In C. Bruguière, A. Tiberghien & P. Clément (Eds.), E-Book Proceedings of the ESERA 2011 Conference: Science learning and Citizenship. Part 5 (co-ed. L. Maurines, & A. Redfors), (pp. 9-15). European Science Education Research Association.

Bolte, C., Schulte, T., Kapanadze, M., & Slovinsky, E. (2012b). Stakeholders’ views on desirable science education in Georgia. In M. Kapanadze, & I. Eilks (Eds.), Student active learning in science (pp.79-84). Ilia State University Press.

Bolte, C., Hofstein, A. (2013). How to Motivate students and raise their interest in chemistry education. In I. Eilks, A. Hofstein (Eds.), Teaching chemistry – A studybook: A practical guide and textbook for student teachers, teacher trainees and teachers (pp. 67-95). Springer Science & Business Media. https://doi.org/10.1007/978-94-6209-140-5_3

Bolte, C., Streller, S., Holbrook, J., Rannikmae, M., Hofstein, A., Mamlok-Naaman, R., & Rauch, F.
Gilbert, J. K. (2011). Concept-Based Science Teaching and Motivation. Free University Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/3op6DuM

Cook, T. D., & Campbell, D. T. (1979). Quasi-experimentation: Design and analysis issues for field settings. Houghton Mifflin.

Devetak, I., Glazar, S. A., Jurišević, M., & Vogrinc, M. M. J. (2014). Students’ motivation and achievements in lower-secondary school science subjects - Slovenian PROFILES perspectives. In C. P. Constantinou, N. Papadouris & A. Hadjigeorgiou (Eds.), E-Book Proceedings of the ESERA 2013 Conference: Science education research for evidence-based teaching and coherence in learning. Part 2 (co-eds. J. Lavonen, & A. Zeyer), (pp.11-18). European Science Education Research Association.

Dori, Y. J., & Herscovitz, O. (2005). Case-based long-term professional development of science teachers. International Journal of Science Education, 27(12), 1413-1446. https://doi.org/10.1080/0950069050102946

Drake, S. M., & Burns, R. C. (2004). Meeting standards through integrated curriculum. Association for Supervision and Curriculum Development (ASCD).

Duranti, A., & Goodwin, C. (Eds.), (1992). Rethinking context: Language as an interactive phenomenon. Cambridge University Press.

Eilks, I., Marks, R., & Feierabend, T. (2008). Science education research to prepare future citizens – Chemistry learning in a socio-critical and problem-oriented approach. In B. Ralle & I. Eilks (Eds.), Promoting successful science learning – The worth of science education research (pp. 75-86). Shaker.

Eilks, I., Rauch, F., Ralle, B., & Hofstein, A. (2013). How to allocate the chemistry curriculum between science and society. In I. Eilks & A. Hofstein (Eds.), Teaching chemistry – A studybook: A practical guide and textbook for student teachers, teacher trainees and teachers (pp. 1-36). Springer Science & Business Media. https://doi.org/10.1007/978-94-6209-140-5_1

Gilbert, J. K. (2006). On the nature of “context” in chemical education. International journal of science education, 28(9), 957-976. https://doi.org/10.1080/09500690600702470

Gilbert, J. K., Bulte, A. M., & Pilot, A. (2011). Concept development and transfer in context-based science education. International Journal of Science Education, 33(6), 817-837. https://doi.org/10.1080/09500693.2010.493185

Glynn, S. M., & Koballa, T. R., Jr. (2006). Motivation to learn college science. In J. J. Mintzes & W. H. Leonard (Eds.), Handbook of college science teaching (pp. 25-32). National Sciences Teachers Association Press.

Hartikainen-Ahia, A., Sormunen, K., Jäppinen I., & Kärkkäinen, S. (2014). Scenarios – A motivational approach towards inquiry-based learning. In C. Bolte & F. Rauch (Eds.), Enhancing inquiry-based science education and teachers continuous professional development in Europe: Insights and reflections on PROFILES and other projects funded by the European Commission (pp. 66-72). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/2M8ZYbg

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. Educational Psychologist, 41, 111-127. https://doi.org/10.1207/s15326985ep4102_4

Hofstein, A., & Kesner, M. (2006). Industrial chemistry and school chemistry: making chemistry studies more relevant. International Journal of Science Education, 28, 1017-1039. https://doi.org/10.1080/09500690600702504

Hofstein, A., & Mamlok-Naaman, R. (2014). From the PROFILES continuous professional development programme to the development of a sense of ownership. In C. Bolte, & F. Rauch (Eds.), Enhancing inquiry-based science education and teachers’ continuous professional development in Europe: Insights and reflections on the PROFILES project and other projects funded by the European Commission (pp. 44-48). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/2M8ZYbg

Hofstein, A., Eilks, I., & Bybee, R. (2010). Societal issues and their importance for contemporary science education. In I. Eilks, & B. Ralle (Eds.), Contemporary science education (pp. 5-22). Shaker.

Holbrook, J., & Rannikmäe, M. (2009). The meaning of scientific literacy. International Journal of Environmental and Science Education, 4, 275-288.

Kapanadze, M., & Eilks, I. (2014). Supporting reform in science education in Central and Eastern Europe - Reflections and perspectives from the Project TEMPUS-SALiS. Eurasia Journal of Mathematics, Science & Technology Education, 10(1), 47-58. https://doi.org/10.12973/eurasia.2014.1016a

Kapanadze, M., & Slovinsky, E. (2014a). Inquiry science education with in the Project PROFILES in Georgia. In C. Bolte, & F. Rauch (Eds.), Enhancing inquiry-based science education and teachers’ continuous professional development in Europe: Insights and reflections on the PROFILES project and other projects funded by the European Commission, (pp. 112-118). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/2M8ZYbg
Kapanadze, M., & Slovinsky, E. (2014b). Teachers' ownership towards developing new PROFILES modules. In C., Bolte, & F. Rauch (Eds.), Enhancing inquiry-based science education and teachers' continuous professional development in Europe: Insights and reflections on the PROFILES project and other projects funded by the European Commission (pp. 118-122). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/2M82Ybg

Kapanadze, M., Bolte, C., Schneider, V., & Slovinsky, E. (2015a). Enhancing science teachers’ continuous professional development in the field of inquiry-based science education. Journal of Baltic Science Education, 14(2), 254-266. https://bit.ly/3op0H5g

Kapanadze, M., Bolte, C., Schulte, T., & Slovinsky, E. (2015b). Stakeholders’ views on science education - Curricular delphi study in Georgia. American Journal of Educational Research, 3(7), 897-906. https://bit.ly/2U1A1SK

Kapanadze, M., Janashia, S., & Eilks, I. (2010). From science education in the soviet time, via national reform initiatives, towards an international network to support inquiry-based science education – The case of Georgia and the project SALiS. In I. Eilks, & B. Ralle (Eds.), Contemporary science education (pp. 237-242). Verlag Shaker.

Kennedy, D., & Lucey, J., (2014). The implementation and evaluation of inquiry-based science education PROFILES modules in second-level schools in Ireland. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), Science teachers’ continuous professional development in Europe: Case studies from the PROFILES Project (pp. 129-138). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/3ooCmwf

Koballa, T. R. Jr., & Glynn, S. M. (2007). Attitudinal and motivational constructs in science education. In S. K. Abell, & N. Lederman (Eds.), Handbook for research in science education (pp. 75-102). Erlbaum.

Krapp, A. (2002). An Educational-psychological theory of interest and its relation to SDT. In: E. Deci, R. Ryan (Eds.), Handbook of self-determination research (pp. 405-427). University of Rochester.

Krapp, A., & Prenzel, M., (2011). Research on interest in science: Theories, methods, and findings, International Journal of Science Education, 33(1), 27-50, https://doi.org/10.1080/095026110.518645

MoES (2015). Ministry of Education, Culture, and Sport of Georgia. www.mes.gov.ge

NAEC (2017). PISA 2015 results (Georgia). National Assessment and Examinations Center, Tbilisi.

NCP (2014). The National Curriculum Portal, Georgia. www.ncp.ge

OECD (2016). PISA 2015 Results (Volume I): Excellence and Equity in Education. PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264266490-en

Osborne, J., & Dillon, J. (2008). Science education in Europe: Critical reflections. The Nuffield Foundation.

Prenzel, M. (1992). The selective persistence of interest. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), The role of interest in learning and development (pp. 71-98). Erlbaum.

PROFILES Consortium (2010). Professional reflection-oriented focus on inquiry-based learning and education through science. www.profiles-project.eu

PROFILES Georgia (2014). Professional reflection-oriented focus on inquiry-based learning and education through science – Georgia. www.profiles-georgia.iliauni.edu.ge

Ryan, R. M., & Deci, E. L. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary Educational Psychology, 25(1), 54-67. https://doi.org/10.1006/ceps.1999.1020

Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68-78. https://doi.org/10.1037/0003-066X.55.1.68

Sadler, T. D., & Zeidler, D. (2009). Scientific literacy, PISA, and socio-scientific discourse: Assessment for progressive aims of science education. Journal of Research in Science Teaching, 46, 909-921. https://doi.org/10.1002/tea.20327

SALiS (2011). Student active learning in science. www.salislab.org

Schindler, D., Markic, S., Stuckey, M., & Eilks, I. (2014). What should I do with my old cell phone? A case of collaborative curriculum development within PROFILES-Bremen. In C. Bolte, J. Holbrook, R. Mamlok-Naaman, & F. Rauch (Eds.), Science teachers’ continuous professional development in Europe: Case studies from the PROFILES Project (pp. 103-119). Freie Universität Berlin / Alpen-Adria-Universität Klagenfurt. https://bit.ly/3ooCmwf

Sjoberg, S., & Schreiner, C. (2010). The ROSE project: An overview and key findings. University of Oslo.

Stolz, M., Witteck, T., Marks, R., & Eilks, I. (2013). Reflecting socio-scientific issues for science education coming from the case of curriculum development on doping in chemistry education. Eurasia Journal of Mathematics, Science and Technology Education, 9(4), 361-370. https://doi.org/10.12973/eurasia.2014.945a

Stuckey, M., & Eilks, I. (2014). Increasing student motivation and the perception of chemistry’s relevance in the classroom by learning about tattooing from a chemical and societal view.
Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of ‘relevance’ in science education and its implications for the science curriculum. *Studies in Science Education, 49*(1), 1-34. https://doi.org/10.1080/03057267.2013.802463

Tuan, H. L., Chin, C. C., & Shieh, S. H. (2005). The development of a questionnaire to measure students’ motivation towards science learning. *International Journal of Science Education, 27*(6), 639-654. https://doi.org/10.1080/0950069042000323737

Wood, R. (2019). Students’ motivation to engage with science learning activities through the lens of self-determination theory: Results from a single-case school-based study. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(7), em1718. https://doi.org/10.29333/ ejmste/106110

World Bank (2006). *Georgia - Education system realignment and strengthening program (English).* World Bank. https://bit.ly/2NJ4jlV

World Bank (2014). *Georgia education sector policy review: Strategic issues and reform agenda.* World Bank. http://hdl.handle.net/10986/26443

Zeidler D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). A research based framework for socio-scientific issues education. *Science Education, 89*, 357-377. https://doi.org/10.1002/sce.20048

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