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Abstract. *Decreasing motivation in science classes is often reported in many countries. Georgia, one of the post Soviet countries, has overcome the highly centralised educational system and nowadays implements a new national educational reform. National reforms demand more student-active and inquiry-based learning. Many Georgian teachers aren't ready for these changes and need professional development training to enhance their professional skills in Inquiry-Based Science Education (IBSE). Therefore Iliia State University offers special continuous professional development (CPD) programs for science teachers in the frame of PROFILES project. The aim of the research was to determine what profession oriented attitudes and concerns Georgian in-service science teachers have regarding IBSE and what changes are visible after the implementation of PROFILES-based CPD programme. In order to conduct the research, the Stages of Concern model was used. 40 teachers took part in the two terms of the CPD programme. Research shows that the implemented CPD programme fosters the professional attitudes and concerns of Georgian science teachers in a positive manner. Therefore, it can be highly recommended to use the framework of the PROFILES-based CPD programme(s).*

Key words: *IBSE, in-service teachers in Georgia, professional development, stages of concern.*

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ENHANCING SCIENCE TEACHERS' CONTINUOUS PROFESSIONAL DEVELOPMENT IN THE FIELD OF INQUIRY BASED SCIENCE EDUCATION

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Introduction

International studies such as TIMSS and PISA show that in many countries students' achievements in science and mathematics are very low (Martin *et al.*, 2011; PISA, 2012, OECD, 2014). Furthermore, the Relevance of Science Education Study, ROSE (Schreiner & Sjøberg, 2004) shows that in many countries, students have only little interest in science and in learning science. Decreasing motivation in science classes is also often reported in many Western European countries (Osborne, 2003). The same seems to be true for Eastern European countries (Janiuk & Mazur, 2010; Zhilin, 2010). In Georgia these trends are also reported (Kapanadze & Slovinsky, 2014); for example, Georgian students' results in TIMSS (2011) are lower than the standard mean (NAEC, 2013).

In order to change this unsatisfying situation in Georgia, various reforms have been initiated to improve the educational system in general and science teaching practice in particular. For example, in Georgia (Sharvashidze, 2003), as well as in other post-Soviet countries, national educational reforms have been started more than 10 years ago. However, in many cases the educational stakeholders and especially the teachers have to face the fact, that the new curricula do not really lead to the success which was expected of these reforms. Innovative, contemporary and effective teaching materials are seldom available and facilities to provide proper training courses or long term professional development programmes for (science) teachers are very rare. This seems to further decrease the level of interest among the students to learn science and impacts their achievements in the science subjects in an undesirable manner.

Facing these unsatisfying situations, the stakeholders of many organisations and institutions in the field of science education recommend a radical change in the ways science is taught in schools. To enhance the motivation of the students and to increase their achievements and competences, the role of the teachers needs to change. As promoted in other Western countries,



there should be a shift from deductive to more inductive methods of teaching in science lessons (AAAS, 2000; National Research Council, 2000; Rocard *et al.*, 2007). In order to foster this change, different reports (AAAS, 2000; National Research Council, 2000; Rocard *et al.*, 2007) suggest, that Inquiry-Based Science Education (IBSE) might be a promising approach to enhance students' motivation and their learning outcomes. In order to change science teaching and learning in the school system, it is clear that teachers must play a very important role if innovation – such as the implementation of IBSE – should take place in schools (Bolte *et al.*, 2012).

In fact, this leads us back to the situation in the field of teacher education and the efforts for teachers' continuous professional development (CPD) and to the conclusion, that there is a need for IBSE-based CPD courses for science teachers. Due to the authors' opinion, this is the only way to enhance successfully the implementation of innovation and educational reforms in the schools and in science education practice.

There are many projects in Europe funded by the European Commission, trying to promote and implement IBSE in the school systems in Europe and beyond (such as projects supported by the EC FP6 and FP7 programmes). One of those FP7 projects is the "PROFILES" project (PROFILES, 2010; Bolte *et al.*, 2011; Bolte *et al.*, 2012). PROFILES is the acronym of "Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science" and is the name of a consortium, which consists of 22 partners from 21 countries.

The PROFILES project "promotes science teacher professionalism through a continuous professional development programme to support teacher self-reflection on the innovative ideas in the project linked to stakeholders' views, inquiry-based learning, student-centered approaches and a thrust for science education, that enhance students' learning in knowledge, skills, attitudes and values" (Bolte *et al.*, 2014, p. 4).

In order to achieve the project aims, PROFILES supports the adoption, creation and development of materials and modules for teaching and learning science, to enhance Inquiry-Based Science Education in the partner countries. The support in adopting and/or creating these materials and modules usually takes place in PROFILES-based science teachers' CPD programmes. PROFILES based-CPD programmes correspond to a specific frame, the PROFILES CPD model. It usually consists of at least 40 hours of coursework (seminars, lectures, workshops etc.). The CPD programme as a whole is divided into three parts: Part I is dedicated to the introduction of the project, to become familiar with the PROFILES project, its aims, approaches and the already existing materials. Beside this, the participants are working on the adaptation of existing PROFILES-based learning environments (also termed as PROFILES Modules) and/or on the development of new modules, which fit for the respective education system. In Part II of the PROFILES CPD the participating teachers are involved in implementing the modules they adapted or developed. In Part III of the programme the teachers meet again, share and discuss their experience, reflect the feedback and insights they received and work on a revision of the modules (if they see the need for this). Finally, the PROFILES teachers disseminate their materials, module insights and experiences. Therefore, a PROFILES CPD programme consists of at least four meetings (with more than 10 hours) or up to 10 or 12 meetings (with approximately 4 hour meetings).

Beside this framework, a PROFILES CPD programme is based on a "four-stage-model" of teachers' professional development; the four stages of this model are focusing on different roles a teacher takes during his/her long term efforts to reach a higher level of professionalism. In the 1st stage, the teacher is acting as a learner; in the 2nd stage, as an effective teacher; in the 3rd as a reflective practitioner; and finally – and maybe only in some, but not all cases – he/she enters the 4th stage, in which he/she is acting as a leader showing a high (or higher) level of ownership, regarding more successful ways of teaching science (Hofstein *et al.*, 2012).

Figure 1 presents the model of the CPD programme, which the PROFILES team at Ilia State University in Georgia created and followed, in consideration of the Georgian science teachers' professional needs.

All PROFILES teaching and learning modules used in the CPD as well as in the participants' classrooms are based on a "three stage model" for science teaching and learning in accordance with the PROFILES philosophy (see Bolte *et al.*, 2012; Holbrook and Rannikmae, 2012) and focusing on:

1. issues connected with everyday life, leading to a scientific question;
2. a student-centered emphasis on scientific problem solving using inquiry; and lead to
3. (socio-scientific) decision-making processes related to the science acquired and in most of the cases to societal needs for responsible citizenship.

Five PROFILES type modules have been adapted by the team of Ilia State University in Georgia for, and revised during the first term of the CPD programme. In addition, five new modules were created by the Georgian teachers participating in the CPD courses during the first and second term of the PROFILES CPD programme (see PROFILES (Georgia), 2013).



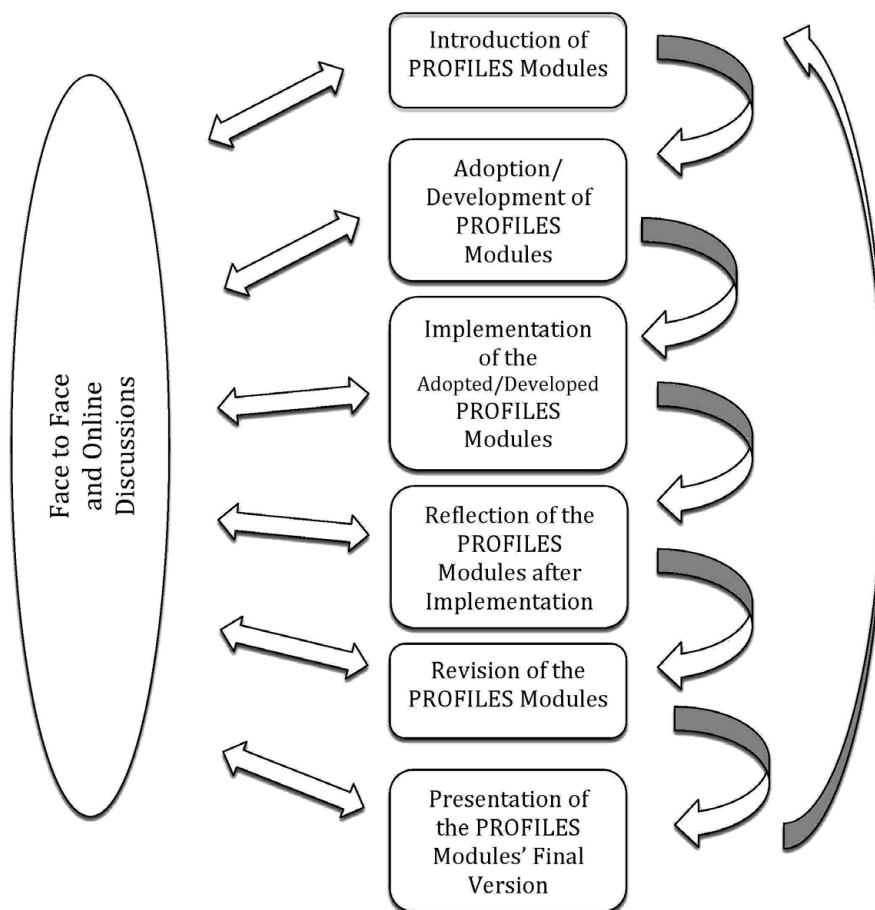


Figure 1: Model of the long term CPD programme at Ilia State University.

Finally, all the adapted or created modules were implemented by the participants of the Georgian CPD programmes. In the framework of this implementation all modules have been assessed by the teachers involved as very supportive in their science teaching and as highly motivating for the students.

Beside this, and in order to evaluate the impact of the Georgian CPD programmes provided at Ilia State University in Georgia, it was decided to analyse the teachers' professional attitudes and concerns, in order to get evidence-based information about the success of the implemented CPD programmes. For the purpose of the CPD evaluation in Georgia the "Concerns Based Adoption Model" and the "Stages of Concerns theory" as introduced by Hall and Hord (2006; 2011) was chosen and a "Stages of Concerns Questionnaire" based on their theoretical assumption was applied.

Following Loucks-Horsley *et al.* (2010) and Hall and Hord (2011), professional development is based on attitudes and concerns. Regarding attitudes, the theory of planned behaviour (Ajzen, 1991) implies that attitudes influence behaviour intentions, and these intentions in turn influence the actual behaviour. For the study purpose, this means positive attitudes towards IBSE by Georgian teachers affect their intention to implement IBSE in school practice. The stronger is the intention to implement IBSE, the more likely IBSE will be performed in practice.

Regarding the term 'concerns', Hall and Hord (2011) state that concern-based professional development processes are a good chance to evaluate the adoption success of innovative programmes trying to increase professionalism in general. Therefore, to gain insights into Georgian in-service teachers' attitudes towards IBSE and the development of those attitudes, the Stages of Concern (SoC) model was used with a specific questionnaire created by Hall and Hord (2011). This SoC model is based on seven "Stages of Concerns", namely: A - Unconcerned, B - Informational, C - Personal, D - Management, E - Consequence, F - Collaboration and G - Refocusing (see Figure 2).



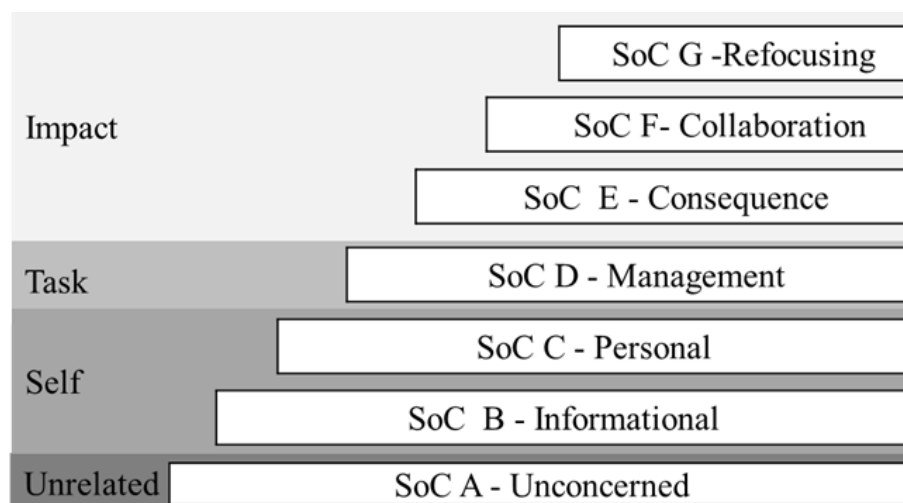


Figure 2: Stages of concern model according to Fuller (1969), Hall and Hord (2011).

The SoC theory was developed in order to investigate teachers' professional development in accordance with studies conducted by Fuller (1969). Fuller (1969) proposed a four-dimensional concern-based model of professional development; with increasing experience in an educational programme or reform, teachers' concerns pass through the four dimensions, termed as: "Unrelated", "Self", "Task" and "Impact" (Fuller, 1969). "Unrelated" means that teachers have not developed or have developed only little concerns regarding the educational programme/reform. "Self" refers to the impact the educational programme has on a person. "Task" covers the management of time or materials, and for "Impact" the focus is on collaboration and the impact of the educational programme on students. Furthermore, Hall and Hord (2011) differentiate the Fuller's concerns model into seven instead of the four stages, and they termed their model the "Stages of Concern" model. Regarding the Hall and Hord seven stage model, Stage A "Unconcerned" is identical with Fuller's stage "Unrelated". Fuller's stage "Self" is modified into two stages, called: "Informational" and "Personal". "Informational" deals with knowledge about the educational programme. "Personal" shows how the use of an educational programme will affect a person. The stage "Management" is identical with Fuller's stage "Task". But once more, the postulated stage of Fuller's label as "Impact" was differentiated by Hall and Hord (2006; 2011) into three stages, namely the Hall and Hord stages: "Consequence", focusing on the impact of the educational programme on students, "Collaboration", referring to coordination and cooperation with others, and "Refocusing" exploring further benefits from the educational programme, including the possibility of improvement.

Hall and Hord (2011) state that a development from stage to stage might be only theoretical – however, practically there is the possibility to identify special SoC profiles, which offer information about professional attitudes of the testees (in this case – of the Georgian in-service science teachers participating in the PROFILES CPD programmes). All in all, applying the SoC model for the evaluation of the Georgian PROFILES-based CPD programme(s) provides information about the teachers' attitudes and their (potential) changes. In this case, their attitudes and professional concerns towards IBSE. The professional development of teachers will be investigated in this research by creating and comparing the so-called "Stages of Concern profiles" (e.g. the 'Cooperator', 'Opponent', 'Non-User', 'Docile Performer' etc.; see Hall & Hord, 2011; or Bitan-Friedlander *et al.*, 2004) of the teachers involved in the Georgian PROFILES CPD programme. The reconstruction of the participating teachers' SoC profiles and the changes of the teachers' professional concerns will provide information about the teachers' professional concerns in general and about their professional development within the long term PROFILES-based CPD courses.

The theoretical framework discussed so far leads to the following research questions:

1. What professional attitudes and concerns do Georgian in-service science teachers show to the implementation of IBSE in the Georgian school system a) at the beginning and b) at the end of the PROFILES based CPD programme?



2. How do Georgian in-service science teachers' professional attitudes and concerns about the implementation of IBSE change in the frame of the Georgian PROFILES-based CPD programme?

Methodology of Research

Design and Sample of the Research

In order to answer these research questions, a pre-post test treatment study was designed. The PROFILES-based CPD programme serves as the treatment and the Georgian in-service science teachers who participate in this CPD programme build the sample. Approximately 20 teachers per CPD term should be involved and it was planned to conduct the PROFILES-based CPD programme at least twice. This leads to a sample of at least 40 Georgian in-service science teachers in total – PROFILES participants during two years – 2013 and 2014. In the first term 19 (7 Biology, 6 Chemistry and 6 Physics) teachers and in the second term 21 (8 Biology, 8 Chemistry and 5 Physics) teachers participated in the CPD courses. The teachers came from different types of schools (public as well as private schools) and from different regions of Georgia. Because of the big interest of many Georgian science teachers in participating in the PROFILES project CPD programme, the teachers who finally participated in the PROFILES CPD courses were selected before the start of a CPD programme via interviews. All the participating teachers attended all the CPD sessions and were actively involved in the adaptation and creation as well as in the implementation and revision of the PROFILES modules.

CPD Programme

The PROFILES professional development courses – serving as the treatment of this research (see above) – are oriented to enhancing specific professional skills of the participating teachers, such as experimenting, investigating, creating, cooperating together. In the frame of the Georgian CPD programmes, different workshops and seminars are organized focusing on how to realize IBSE in Georgian science classrooms. Creative thinking, problem solving and designing learning environments emphasizing socio-scientific issues and concerns, were introduced by the CPD providers as well as discussed and worked out by the participating teachers. After implementation of PROFILES modules, further discussions took place in different sessions. Finally, revised PROFILES modules were created by the teachers themselves and presented at a PROFILES National Conference at Ilia State University.

Both CPD terms should consist of at least 50 hours of seminars and workshops; most organized as face to face meetings and some as online seminars (see Figure 1). The structure of the CPD programme can be differentiated into three periods:

1. The first period is dedicated to the introduction of IBSE and to the work on the adaptation and/or development of PROFILES modules, which fit to the situation in the Georgian school system and to the professional needs expressed by the participating teachers, in order to enhance their students' motivation to learn science.
2. In the second period of the CPD programme, the teachers use the PROFILES modules they adapted or developed in the frame of the CPD courses and test their suitability in their science lessons.
3. In the third period, the teachers share their experiences teaching the modules with the other participants and discuss the strengths and weaknesses of the module implementation. It is expected that the teachers may offer the need to improve some (or maybe many) of the modules they piloted and tested in their practice. If needed, the improvement of the modules adapted or created so far takes place in this period before the participating teacher may start a further trial of teaching using the PROFILES modules.

The structure of Georgian CPD programme is shown in Table 1.



Table 1. Structure of the CPD programme.

CPD Programme		
	Content	Duration in hours
Preparation	Introduction, planning, information about the PROFILES project Introduction of the concept of Scientific Inquiry and IBSE activities Introduction of the PROFILES modules	11 - 13
	Adoption and development of existing PROFILES modules Ideas and development of PROFILES new modules Improvement of PROFILES new modules Presentation and discussion adapted or developed PROFILES modules	17 - 19
Implementation		
Revision	Presentation and sharing experiences after implementation of the adapted/ developed PROFILES modules Reflection and discussions of how to improve the implemented PROFILES modules	8 - 9
	Revision of the PROFILES modules based on vivid discussions	8 - 9
	Presentation of the PROFILES modules	3

The structure of both CPD terms as well as the total duration and numbers of the sessions before and after the implementation of the PROFILES modules are the same. 30 hours are dedicated for the teachers' preparation before they implement at least one of the PROFILES modules and 20 hours of meeting are foreseen after the module implementation for reflection and the improvement of a module (in case this is needed).

Questionnaire

For the analysis and in order to answer the research questions the German IBSE SoC questionnaire version of Schneider and Bolte (2011), which they developed according to Hall and Hord (2006; 2011), was adapted. The German SoC questionnaire was tested successfully in different studies (e.g. Schneider & Bolte, 2012; Bolte & Schneider, 2014; Bolte, Schneider & Schürmann, 2014; Schneider, Bolte & Krischer, 2015) before it was translated into Georgian language. This SoC questionnaire version focuses on IBSE. The SoC questionnaire consists of 41 items representing the seven "Stages of Concerns" introduced by Hall and Hord (2011). The stages A, D, E, F are represented by five items and stage B by seven, C by six and G by eight items in the prepared questionnaire. Table 2 shows the seven SoC scales and one exemplary item (in English) per scale.

Table 2. Description of stages of concerns.

Stages of Concern	Exemplary items
SoC A: Unconcerned	I am more concerned about other topics than 'Inquiry Based Science Education' at this time.
SoC B: Informational	I would like to know how the teaching concept 'Inquiry Based Science Education' can be designed.
SoC C: Personal	I would like to know how much effort it will take me to adapt existing materials for the teaching concept 'Inquiry Based Science Education'.
SoC D: Management	I am concerned about not having enough time to handle all requirements of the teaching concept 'Inquiry Based Science Education'.
SoC E: Consequence	I am concerned about how the teaching concept 'Inquiry Based Science Education' affects students.
SoC F: Collaboration	I would like to help other teachers in planning and using the teaching concept 'Inquiry Based Science Education'.
SoC G: Refocusing	I would like to enrich the practice of the teaching concept 'Inquiry Based Science Education'.



According to Schneider and Bolte (2012) as well as Hall and Hord (2011), each item has a rating scale from 1 "Not true of me now" to 7 "Very true of me now". Furthermore, if the content of an item is currently not relevant to a person at all, there is also the possibility to choose the scale "irrelevant". The option "irrelevant" is coded in the data pool as 'missing value'. As the SoC questionnaire in the Georgian language was administered for the first time, it was necessary to check the scientific quality of the seven SoC scales by conducting reliability and factor analyses. If these tests fit the criteria of scientific quality the data collected can be analysed using different statistical methods (see below).

Data Collection and Analyses

To get insights into Georgian in-service science teachers' professional attitudes and concerns and their changes, the Georgian SoC questionnaire is administered to the in-service teachers of the treatment group twice: (1) at the beginning of the treatment – the PROFILES CPD programme – (pre-test) and (2) at the end of the CPD programme (post-test).

In order to use an SoC questionnaire for Georgian in-service teachers' professional attitudes and concern and their development(s), the scientific quality of the adapted questionnaire version has to be evaluated. Therefore, the calculation of Cronbach's α for each scale is the first step of the analyses. This objective leads to the 3rd research question:

- Does the Georgian IBSE-related SoC questionnaire meet the criteria of scientific quality? Or to express this objective in other words: Which items represent the respective scale (stage of concerns) in a reliable manner (Cronbach's $\alpha > 0.60$)?

To answer the research questions 1 and 2 the data of only those participants who took part in the pre- and post-tests are included in the statistical analyses. To analyse the SoC profiles of the treatment group, mean scores of each SoC scale (according to Schneider & Bolte, 2012) are calculated for both times of collection (for the pre-test data and the post-test data). The mean scores of each SoC scale per time of data collection are connected with a line in accordance to Hall and Hord (2011) and as Bitan-Friedlander *et al.* (2004) recommended, in order to illustrate and compare the SoC profiles of this study participants at both times of measurement.

To test whether the participants' SoC assessments differ in a statistically significant manner, a dependent t-test ($p < 0.05$) is conducted. Beside the identification of statistically significant differences, effect sizes (Cohen's d) are calculated in addition.

Following this strategy, scientifically sound and empirically based evidence concerning the development of the participants' professional attitudes and concerns regarding the implementation of IBSE, are expected (see research question 2).

Results of Research

Psychometric Features

As mentioned above, the first step of the analyses was dedicated to test the scientific quality of the adapted SoC questionnaire and its translation into the Georgian language. This had been done using reliability and factor analyses. Table 3 shows the results of the reliability analysis. Cronbach's α of the SoC scales ranges from $\alpha > 0.6$ to $\alpha < 0.7$. Considering these reliability coefficients, it can be stated that the modified version of the Georgian SoC questionnaire is scientifically sound and provides reliable scales. However, in order to reach these satisfying reliability coefficients, some items had to be excluded in the process of reliability and factor analyses.

Table 3. Cronbach's α of SoC scales.

	SoC A	SoC B	SoC C	SoC D	SoC E	SoC F	SoC G
N_{Items}	3	4	4	3	3	4	3
N_{Teachers}	40	40	40	40	40	40	40
Cronbach's α	0.6	0.6	0.7	0.6	0.6	0.6	0.6



Nevertheless, using the scales of the revised SoC questionnaire version (based on the selected items only), the calculations of 'the SoC profiles' of the teachers pre- and post-test assessments, and hence the evaluation of the impact of the PROFILES-based CPD programme – became possible.

SoC Profiles

According to the revised version of the SoC questionnaire, the mean values for the seven SoC scales were calculated. These mean values per SoC scale were combined into one graph in Figure 3 as described below. The findings of the teachers' pre- and post test assessments are separately illustrated in Figure 3 and the results of the analyses are summarized in Table 4.

The results of the pre-test analyses show the profile of a mean value of a SoC scale "M" if we take out of the consideration the SoC scale G "Refocusing" (see Figure 3). This profile indicates that the teachers can be described as "cooperative and open minded" regarding an innovation, in these cases regarding the implementation of IBSE in Georgian schools. In the pre-test, the mean values of six (out of seven) SoC scales are higher than the theoretical mean value (4.0). Especially the mean values of the SoC scales "B – Informational", "C – Personal", "E – Consequence" and "G – Refocusing" reach nearly the maximum level (7.0). These findings indicate the teachers' special needs for more and further information (SoC B) concerning the term IBSE and that they are concerned about what the implementation of IBSE may demand from them personally (SoC C). Besides this, the teachers wonder how IBSE may impact on their students' learning and their learning outcomes (SoC E). Furthermore, the teachers involved in this study reflect already at this (early) stage of their CPD programme their concern as to how IBSE-oriented teaching could be improved (SoC G).

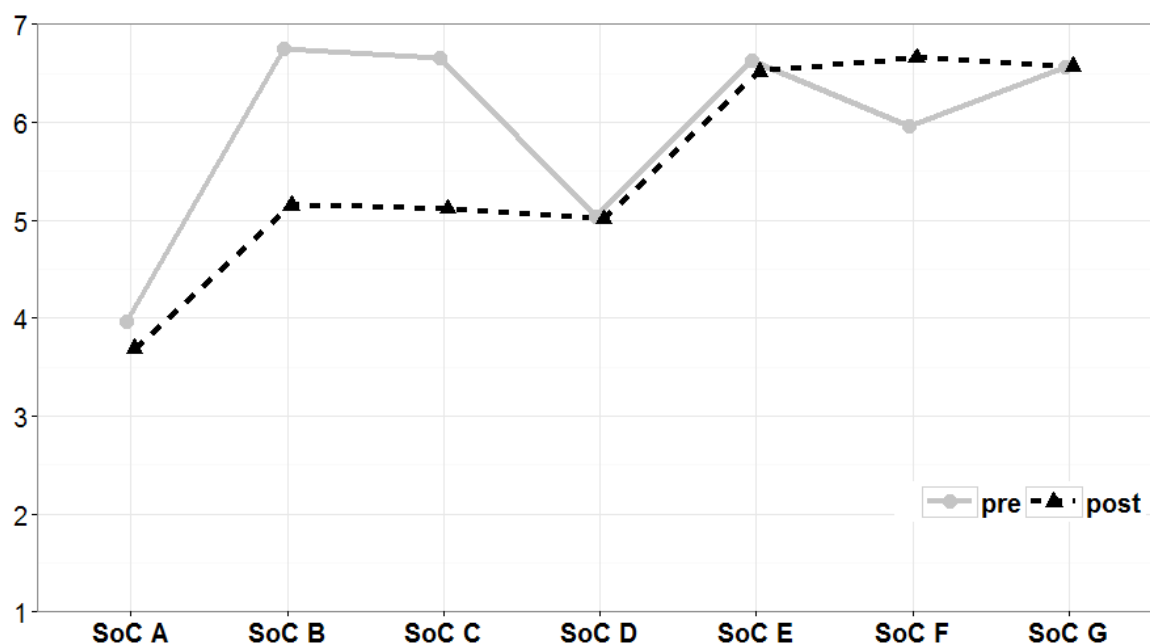


Figure 3: SoC Assessments in the pre- and post- tests of Georgian in-service science teachers (treatment group – N=40) – Mean scores of the seven different Stages of Concerns (SoC) scales: SoC A: "Unconcerned"¹, SoC B: "Informational", SoC C: "Personal", SoC D: "Management", SoC E: "Consequence", SoC F: "Collaboration" and SoC G: "Refocusing" (Differences regarding SoC B, SoC C and SoC F are statistically significant [$p < 0.001$]; see Table 4).

1 Please note: A high value on the SoC-Scale A "Unconcerned" means that the test persons' awareness about IBSE is on a low level,



Table 4. Comparison of Georgian in-service science teachers' SoC assessments in the pre- and post test analyses (treatment group – N=40) – Mean scores (M), Standard Deviation (SD), p value [$*p<0.05$; $p<0.01$; $***p<0.001$] and Cohen's d regarding the seven different Stages of Concerns (SoC) scales: SoC A: "Unconcerned", SoC B: "Informational", SoC C: "Personal", SoC D: "Management", SoC E: "Consequence", SoC F: "Collaboration" and SoC G: "Refocusing".**

	SoC A		SoC B		SoC C		SoC D		SoC E		SoC F		SoC G	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Pre tests	3.96	1.34	6.75	0.48	6.65	0.58	5.03	1.37	6.63	0.71	5.96	0.96	6.56	0.73
Post tests	3.69	1.58	5.15	1.83	5.11	1.95	5.01	1.38	6.52	0.72	6.66	0.83	6.57	0.77
p	n. s.		***		***		n. s.		n. s.		***		n. s.	
d	/		0.93		0.82		/		/		0.78		/	

The SoC profile of post-test findings differs from the one of the pre-test analyses. The lowest mean value is found for the SoC scale A ("Unconcerned"; $M=3.69$); the participants of the CPD are now – at the end of the CPD programme – obviously aware of the 'IBSE' approach in general. However, the teachers still express their interest in getting more information about the term IBSE and the theoretical framework behind this educational concept (SoC B: Informational; $M=5.15$), and that they are still concerned about the question as to how the implementation of IBSE may impact themselves in their role as a science teacher (SoC C: Personal; $M=5.11$). Compared to this, at the end of the CPD programme the "impact" scales (according to Fuller (1969) and Hall and Hord (2006) the SoC scales: "E - Consequence", "F - Collaboration" and "G - Refocusing") are assessed significantly higher than the before-mentioned "unrelated" scale (SoC A), "self" scales (SoC B and SoC C) and "task" scale (SoC D). The SoC profile received from the post-test analyses could be considered as a 'mirror image' to the SoC profile which is termed – for example by Hall and Hord (2011) – as a profile of a "non-user". A "non-user" is described as a person who shows negative attitudes concerning an innovation. Therefore, it can be concluded, that teachers who show an opposite profile can be characterized as persons highly interested in and motivated to support the innovation. Surprisingly a SoC profile like this has not been labeled before. Hence, a SoC profile like this and the prototype showing this SoC profile in the context of an educational innovation was termed as "innovative practitioner", because teachers with such SoC profile of professional attitudes and concerns are highly motivated to implement an educational innovation (for example the implementation of IBSE), as they are convinced that the innovation will have a positive impact on their professional practice.

Comparing the results of the pre- and post-test analysis, the following changes in the teachers' assessments can be ascertained: regarding the SoC scales A ("Unconcerned"), B ("Informational") and C ("Personal") the mean values of the post-test assessments are lower than the teachers' assessments in the pre-test. The mean values of the SoC scales D ("Management"), E ("Consequences") and G ("Refocusing") are in the pre-test – overall – nearly on the same level than they have been in the post-test analyses. Looking at the SoC scale F ("Collaboration"), it is visible that the mean value of this scale is higher in the post-test analysis than on the pre-test.

The t-test analyses of the SoC scales A, D, E and G do not show any statistically significant changes regarding the teachers pre- and post-test assessments. However, the SoC scales B ("Informational"), C ("Personal") and F ("Collaboration") show statistically significant changes and huge effect sizes (Cohen's d) are observed regarding the teachers' pre- and post-test assessments of these SoC scales. Looking at the SoC scales B ("Informational") and C ("Personal"), the analyses show a statistically significant decrease of the teachers SoC assessment and concerns. Opposite to this, it can be ascertained a statistically significant increase of the teachers' SoC assessment, concerning the SoC scale F ("Collaboration").

Discussion

The empirically based findings mentioned above conform to the theoretically-based assumptions and fit the objectives of the PROFILES project in general and the aims of the PROFILES CPD programme in particular. What is more, the findings of this pre-post test treatment study are in agreement with the Stages of Concerns theory and



to prior research results (see Hall & Hord, 2006; 2011; Bitan-Friedlander *et al.*, 2004; Schneider & Bolte, 2012; Bolte, Schneider & Schürmann, 2014).

The analyses show that a scientifically-sound SoC questionnaire version with reliable scales is now available for further research. The reliability coefficients for each of the SoC scales are sufficient (Cronbach's $\alpha > 0.6$). Hence the adapted and translated SoC questionnaire is suitable for analyzing Georgian in-service science teachers' professional attitudes and concerns in general, and the implementation of IBSE in school practice in particular. By means of this SoC questionnaire it is possible to reconstruct the professional attitudes and concerns of Georgian in-service science teachers, both at the beginning and at the end of a specific long term CPD programme, in which the teachers were actively involved. Moreover, this SoC questionnaire provides the opportunity to analyze changes regarding the science teachers' professional attitudes and concerns and to re-construct specific aspects of their professional development. After the removal of some poor SoC items, the Georgian SoC questionnaire in its final version consists of 24 items representing the seven SoC scales as introduced by Hall and Hord (2006; 2011).

At the beginning of a specific treatment (the Georgian PROFILES-based CPD programme) the science teachers who participated in this treatment study showed a SoC profile which has already been identified in many other studies (e.g. Bitan-Friedlander *et al.*, 2004; Pant *et al.*, 2008; Schneider & Bolte, 2012) and which was labeled by Hall and Hord (2006) as the profile of a "cooperator". A cooperator shows positive attitudes towards an innovation and is described as an open-minded person. A person with the attitude profile of a cooperator is highly interested in getting information about the innovation (SoC B) - in this research: about IBSE and how to implement this in science lessons. Furthermore, cooperators reflect at a high level on how the innovation (here IBSE) may affect their personal interest and their professionalism (SoC C), as well as their students' (inquiry) skills (SoC E). Finally, a cooperator is also looking forward to cooperating with colleagues and is seeking for collaboration to support an innovation; in this case the Georgian science teachers are looking for cooperation to implement IBSE in their classrooms.

At the end of the treatment (the Georgian PROFILES-based CPD programme) the science teachers, who participated in this treatment study, were still highly motivated to implement IBSE in their schools; they still express the need for further information regarding IBSE and how to implement this educational concept. Also, they are still reflecting on how IBSE affects their work in the classrooms, but these concerns are now located at a lower level compared to the level of their concerns analysed when they started the PROFILES-based CPD programme. Obviously, they received a lot of information about IBSE in the CPD programme and they experienced how to teach science using inquiry. Therefore, it can be concluded that - because the teachers became familiar with IBSE and experienced how IBSE impacts their students' learning - they then wanted to know more. This conclusion is in line with the teachers' assessment of the SoC scale "F - Collaboration" at the end of their CPD term, because at this stage the participating teachers expressed their wish to cooperate with other colleagues in order to further implement IBSE in their teaching practice. The teachers' willingness to cooperate and to collaborate was significantly increased during the PROFILES-based CPD programme.

The changes in the teachers SoC assessments from the pre- to the post-test polling of the SoC scales B ($p < 0.001$, $d = 0.93$), C ($p < 0.001$, $d = 0.82$), and F ($p < 0.001$, $d = 0.78$) are statistically significant and these differences are combined with huge effect sizes (Cohen's d). According to Eid, Gollwitzer and Schmitt (2011, p. 353) an effect size higher than 0.57 is assessed as large. The effect sizes found in this research are much higher ($0.78 < d < 0.93$) and it can be ascertained, that the treatment - the Georgian PROFILES-based CPD programme - really had a large impact on the participating teachers' professional development, if the focus is on their professional attitudes and concerns regarding the implementation of IBSE in the Georgian school system. Looking back to the general and overall question of this research, based on the findings of the analyses, one can summarize: The PROFILES-based (IBSE-oriented) CPD programme - as it was adapted and realized by the PROFILES team at Ilia State University in Tbilisi, Georgia - fosters the professional attitudes and concerns of Georgian science teachers in a positive manner. With respect to the Theory of Planned Behaviour (Ajzen, 1991), there is a high probability that these PROFILES teachers will further implement IBSE in their school practice. Further follow-up investigations should show to what extent the teachers will really implement IBSE in their science lessons.

One objective of the PROFILES-based CPD programme was (and still is) to inform teachers about IBSE and to convince them to follow this approach as often as possible in their lessons, because of the impact IBSE has on students' gains (see Table 1). The results regarding SoC "B - Informational" and "C - Personal" therefore agree with the theory. But what is more, as the teachers were increasingly willing to cooperate with others (SoC F) to improve and share their knowledge and professional competences, this can be seen as evidence that the teachers' motivation to improve their science teaching and the learning of their students by implementing IBSE was enhanced



during, and because of, the long-term PROFILES-based CPD programme. This conclusion can be underlined looking at the mean value of the SoC scale "G - Refocusing" ($M=6.57$), which is quite near to the maximum of the used seven-point-rating-scale. This high mean value shows that the Georgian teachers involved in this research and in the PROFILES-based CPD programme, seem to be convinced that it is possible and necessary to further improve science education practice. The high mean value of the SoC scale "F – Collaboration" reveals that they are motivated and willing to do this.

All in all, the teachers' professional development can be assessed as (very) positive and as a success, regarding the treatment which was chosen for this treatment study. In other words, the results of this research give empirical evidence that the PROFILES-based CPD programme, dedicated to the implementation of IBSE, was realized successfully in Georgia.

Therefore, it can be highly recommended to use the framework of the PROFILES-based CPD programme(s) and to repeat the CPD programme as often as possible.

Conclusions

On the basis of this research it can be concluded that the "Stages of Concerns theory" introduced by Hall and Hord (2006; 2011) is a useful tool to reconstruct teachers' professional attitudes and concerns in a differentiated and scientifically-sound manner. What is more, by means of the SoC theory and using the SoC questionnaire based on this theory, it is possible to assess and evaluate the impact of a specific treatment, which is theoretically sound and based on empirical evidence.

This research underlines the value of the PROFILES-based CPD programme in general and especially the PROFILES CPD programme created and realized by the PROFILES team at Ilia State University in Georgia and their CPD providers. On the basis of the data analyses, it can be ascertained that the Georgian science teachers who participated in this treatment study showed a very high level of professional concerns regarding the implementation of Inquiry-Based Science Education (IBSE) in the Georgian school system.

Finally, the authors are still convinced, that educational reforms without proper involvement of teachers lead and will lead in future into a dead end (see Introduction). Educational reforms and innovation within the school system have to be combined with sophisticated teacher involvement. PROFILES-based CPD programme reveals how step by step improvement in science education becomes a real possibility, by actively involving teachers. Therefore, it can be recommended the use of the framework of the PROFILES-based CPD programme, adapted, and if necessary modified, in order to improve the practice of science teachers' professional development and to strengthen science education in schools. This will finally lead to the enhancement of scientific literacy of more and more students and citizens, both in the Western and the Eastern European countries.

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