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Finnish Science Teachers' Views on the Three Stage Model

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ABSTRACT: The core idea of the PROFILES project is to support science teachers' continuous professional development. The instructional innovation of the PROFILES is the so called Three Stage Model (TSM) which aims to arouse students' intrinsic motivation, to offer a meaningful inquiry-based learning environment and to use the science learning in socio-scientific decision making. Incorporation of innovations, like the PROFILES philosophy with the TSM, in teachers' daily work is seen here as a frame for their professional development in science teaching. When introducing a new instructional model, e.g., the TSM, to be implemented in science teaching, it is important to first listen to the teachers and grasp their initial views. This is organized by the use of focus group interviews during the first teacher meeting in the Finnish PROFILES program in order to find out, what kind of prior views the teachers have related to the TSM, to its planning and to its implementation in the classroom. The results of this study reveal crucial points that need attention within teacher professional development to implement the TSM. The teachers need, also, to be encouraged to place more trust in their students' abilities: detailed instructions (structured inquiry) might not be needed unless the students ask for them. When the PROFILES-like projects pay attention to explicit consideration to the classroom and school contexts in which teachers work, and emphasize the opportunities to implement new pedagogies in these contexts, teachers can develop strategies for overcoming such constraints. Acknowledging the teacher's voice is a crucial factor for adapting any professional development towards teachers' ownership of new developments.

KEY WORDS: Continuous professional development, teachers' concerns, socio-scientific issues, three stage model

INTRODUCTION

The focus related to students' scientific literacy is moving from educating scientists to young citizens who are equipped with skills needed in an innovative and responsive society – advanced skills related to collaboration, problem-solving, reasoning, decision-making, and communication (cf. Valdman, Holbrook & Rannikmäe, 2012). One way to reach these skills is to see science education as 'education through

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science;' that means, in short, that education is the major focus, irrespective of whether it is undertaken within science teaching, or teaching within any other discipline (Bolte et. al, 2012). Science teaching needs to focus on an appreciation of the actual nature of science, the development of personal learning attributes and the development of social abilities, as well as scientific conceptual development (Holbrook & Rannikmäe, 2007). In order to educate future (scientifically) literate citizens, we need to stimulate students' intrinsic motivation for learning science. One way to reach that goal is to change the emphasis in science education from teacher-centred and content-oriented approaches to an inquiry-based, everyday issue approach (European Commission, 2007). In order to stimulate students' intrinsic motivation, we need to increase students' interest in science learning and show its relevance to them; the latter meaning that learning science is valuable, meaningful and useful for students, themselves. One way is to use real-life examples and relating learning materials to everyday applications, drawing cases from current newsworthy issues, giving local examples and relating theoretical and conceptual knowledge to practice. (Rannikmäe, Teppo & Holbrook, 2010.) Socio-scientific issues, i.e. issues that bring together scientific knowledge with a social context, in which personal, ethical and lawful considerations (Robertshaw & Campbell, 2013) can be seen fulfilling needs and interests, both of students and of society.

To enable students to engage in purposeful science learning, their teachers require adequate knowledge and skills of effective instructional strategies. Professional development aims to expand and improve the learning opportunities that teachers provide for students by altering teachers' beliefs and enabling them to engage in reform-orientated instructional practices (Lee, Hart & Enders, 2004). One of the ongoing projects concerning science teachers' professional development is the so-called, PROFILES project, funded by EU's FP7 programme (see, e.g. Bolte et al., 2012). The core idea of the PROFILES project is to support science teachers' continuous professional development, the ultimate target being to raise teachers' self-efficacy and identify evidence of ownership of PROFILES for the purpose of enhancing students' scientific literacy (Holbrook & Rannikmäe, 2012).

The instructional innovation of the PROFILES is a so-called Three Stage Model (TSM), which aims to arouse students' intrinsic motivation, undertaken in a student-familiar, socio-scientific context, offer a meaningful inquiry-based learning environment, and make use of the science learning to make socio-scientific decisins (cf. Bolte et al., 2011). The incorporation of innovations in teachers' daily work, like the TSM, can be seen as one of the main components of their professional development (Bitan-Friedlander, Dreyfus & Milgrom, 2004). In this article, we describe and elucidate teachers' first views on the TSM.

CONCEPTUAL FRAMEWORK

Three Stage Model as an instructional innovation

The Three Stage Model is designed to promote students' intrinsic motivation to become more interested and engaged in the learning of conceptual science ideas and to undertake inquiry learning and, in particular, meet the aims of 'education through science' (cf. Valdman, Holbrook & Rannikmäe, 2012). The following description is based on the presentation of the TSM by Bolte et al. (2012).

Stage 1 ('Scenario') of the model is meant to arouse students' intrinsic motivation, undertaken in a student-familiar, socio-scientific context. An intention is to involve students in undertaking activities that relate to better understanding of the issue – an issue seen by students as relevant to their lives, not simply relevant to the curriculum – and worthy of greater appreciation. The motivation is intended to start with a carefully worded title and a scenario, purposely a surprising phenomenon in nature, or of students' everyday life, or socio-scientific issues. In facilitating the move to the second stage, the initial motivation forms a key launching platform for the intended science learning. It seeks to draw the students' attention to thinking about deficiencies in their desire to undertake a meaningful discussion, related to the scenario. This facilitates the posing of the scientific question, or questions intended for investigation.

Stage 2 ('Inquiry') is expected to sustain the motivational learning from Stage 1 and to meet learning outcomes that relate to science cognitive gains, operationalise scientific process skills through the intended inquiry-based learning, develop personal attributes (e.g., creativity, showing initiative, perseverance, and safe-working) and also promote students' social development through collaborative teamwork. These processes, together with the learning outcomes from inquiry, facilitate the move to consolidation that which can be enacted through e.g. interpretation of the outcomes, presentation of the findings and discussion on the relevance and reliability of the outcomes.

Stage 3 ('Decision-making') is the consolidation phase for the science learning, in which the acquired science ideas are given relevance by including them back into the socio-scientific scenario, which provided the initial student motivation. This enables the students to reflect on the issues, while placing the newly learned science alongside other attributes important for participating in argumentation and reasoning to reach consensus, first within a small group and then for the class as a whole. This can take place in a range of formats e.g. argumentation debates, role playing, or discussion, so as to derive a justified, society-relevant, decision, or a consideration seen as reasonable by the class.

Teacher's beliefs and concerns related to instructional innovation

Imposing curricular reform, or instructional innovations in a 'top-down' fashion, whereby teachers are expected to just implement the developers' philosophy, ideas and intentions, has been shown to be ineffective in introducing curricular and educational innovations into schools (Blonder et al., 2008). 'Top-down' approaches have often been unsuccessful, because they fail to acknowledge teachers' existing knowledge, beliefs and attitude (van Driel, Beijaard & Verloop, 2001). The incorporation of innovations in teachers' daily work is one of the main components of their professional development. And the main method for the introduction of educational innovations is usually in-service teaching (Bitan-Friedlander, Dreyfus & Milgrom, 2004). Effective professional development programs should take into consideration the beliefs and knowledge held by teachers and find ways for teachers to make their implicit knowledge and beliefs explicit (Gray & Bryce, 2006).

Clarke and Hollingsworth (2002) have modelled teacher professional growth by the so-called 'interconnected model.' The model suggests that change occurs through the mediating processes of 'reflection' and 'enactment' in four distinct domains, which encompass the teacher's world: the personal domain (teacher knowledge, beliefs and attitudes), the domain of practice (professional experimentation), the domain of consequence (salient outcomes), and the external domain (sources of information, stimulus or support). The external domain differs from the other three, because it does not belong to the teacher's world. The three others constitute the individual teacher's professional world of practice, encompassing the teacher's professional actions, the inferred consequences of those actions and the knowledge and beliefs, which prompted and responded to those actions.

When compared to the interconnected model related to how TSM is usually introduced in the PROFILES project to a group of teachers, we can consider ourselves, the local professional development providers, belonging to the external domain – offering information of the new instructional approach and giving stimulus to the teachers. Each of the participating teachers has his, or her own beliefs and attitudes related to science teaching (cf. Clarke & Hollingsworth, 2002). When introducing a new instructional model e.g. TSM, into science teaching, it is important to first listen to the teachers and grasp their related initial views. When we use, here, the concept ' *teacher's views*,' we combine the concepts of '*beliefs*' and '*attitudes*' (cf. Clarke & Hollingsworth, 2002) with a concept of '*a teacher's concern*.' A teacher's concern can be described as "the composite representation of the feelings, pre-occupation, thoughts and considerations given to a particular issue or task" (Hall & Hord 1987, p. xxii). As TSM can be considered as an educational innovation, it needs to be introduced in a way that takes into account teachers' prior views

(Bitan-Friedlander et al., 2004). Their prior views are conceptualized in our analysis by utilizing the features of the so-called ‘Stages of Concern’ model by Hall and Hord (2011). The model consist of four categories: unrelated concerns, concerns related to “self,” “task” and “impact;” see Table 1.

Table 1. Stages of Concern (Hall & Hord, 2011)

Category	Stage	Description
Impact	Refocusing	Individuals at this stage are beginning to understand the universal benefits of the change. They now understand that the change was needed and why it was needed. Individuals at his level may begin to make changes to the innovation to achieve better outcomes.
	Collaboration	Individuals at this stage have begun to work with others and discuss their opinions of the innovation. They are beginning to wonder how their colleagues are implementing the innovation and begin to seek this information.
	Consequence	Individuals at this stage have their attention focused on the impact that the innovation will have on their students.
Task	Management	Individuals at his stage are focusing on the process and the task involved for the innovation. They are also trying to understand the best way to use the resources and information to implement the innovation.
Self	Personal	Individuals at this stage are aware of the change initiative but are unaware of their role in the process. They may be considering personal conflicts (values, moral, beliefs) or may feel as though they are lacking the ability to implement the change initiative.
	Informational	Individuals who are in this stage are aware of the change initiative and are beginning to seek information about the change.
Unrelated	Unconcerned	Individuals are not concerned about the change initiative because they have other things on their mind.

In initiating PROFILES teaching in Finland, two groups of science teachers were first guided by the PROFILES philosophy and the TSM. Examples of earlier produced teaching sequence modules were then reviewed, in small groups, during the first meeting of the teachers. Following that, we organized a focus group discussion for the teachers in order to find out what kind of prior views the teachers held related to: the TSM, to its planning and to its implementation in the classroom. Our research question was thus to find out what kind of views Finnish science teachers held about the TSM.

METHODOLOGY

The study target groups, altogether 30 teachers, consisted of participants in PROFILES meetings, first in August 2011 (the first cohort with 21 teachers) and second in August 2012 (the second cohort with 9 teachers). The teachers were mainly physics and chemistry teachers, teaching in lower (grades 7-9; n = 13), or upper secondary schools (grades 10-12; n = 6), with 6 teaching at both levels; 3 are primary teachers (grades 5-6), and a further 2 teach physics and chemistry in both primary and lower secondary levels (grades 5-9); see details in Table 2.

Table 2. Teachers who participated in the focus group discussions

School level	Subjects	Teachers (n)
Primary (grades 5-6)	Biology-Geography, Physics-Chemistry	3
Lower secondary (grades 7-9)	Physics, Chemistry, Biology	13
Primary (grades 5-6) and lower secondary (grades 7-9)	Physics-Chemistry, Physics, Chemistry	2
Lower secondary (grades 7-9) and upper secondary (grades10-12)	Physics, Chemistry	6
Upper secondary (grades 10-12)	Physics, biology, chemistry	6

In order to gather the teachers' (N = 30) prior views on TSM, we applied a focus group interview approach. A focus group is a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research (Powell & Single, 1996). Focus group interviews rely on the interactions and dynamics between the researcher and the participants within the group, in relation to topics that are provided by the researcher (Blonder et al., 2008). The teachers were grouped into eight discussion groups, each with 3–5 teachers (Group 1, … Group 8). We used mixed groups, i.e., the teachers were not grouped according to their school level, or their subjects, because we interested in their views at a more general level than concentrating on a certain school level or subject. The following discussion topics were given to the teachers: formulating the Scenario; transition from Scenario to Inquiry; assuring content learning; exploitation of results for Decision-making. The discussions in each group were audio-recorded; the length of the recordings varied from 35 to 42 minutes and they were transcribed for analysis. The analysis was based on the method of content analysis and the approach was phenomenological. The thematic texts were categorized with the use of Atlas/ti software.

FINDINGS

Teachers' discussions in focus groups were categorized in six categories, which have several sub-categories (Table 3).

Table 3. Categories of teachers' views

Category	Number of Mentions
Scenario phase	**40**
Different interests of pupils and teachers	10
How to create relevant scenario	8
How to create a natural scenario	5
Do I have enough imagination?	4
Is the scenario simple enough?	4
How to be comfortable with the scenario	3
Ethical questions	2
Use of existing scenarios	2
How to move from scenario to the inquiry phase	2
Inquiry phase	**33**
Do pupils understand/learn concepts/content	17
Need for explicit instructions	13
Teacher summarizing	3
Decision making phase	**22**
Difficulty to make justified decision	9
Questions in the decision making to help	5
Transfer from the inquiry phase	4
How to go back to theissue	3
Decision making same as conclusion in inquiry phase	1
Pupil characteristics	**12**
Differences between pupils and groups	7
No skills	3
Learning problem/interest in general	2
Time resources	**11**
For creating scenarios	6
In general with TSM	5
Teacher's role	**10**
Participation in pupils' work	7
Sharing ideas/experiences helps	3
Total	**128**

We present the key findings of the categories with some teacher quotations (here we do not specify quotations from an individual teacher, instead a discussion group is indicated, e.g., G3 refers to a quotation taken from the discussion in Focus Group 3). The findings, based on the focus group discussions, are conceptualized with the help of Stages of Concern concepts (cf. Bitan-Friedlander et al., 2004; Hall & Hord, 2011). The general impression based on the discussions is that all teachers had a positive attitude to, and they were interested in, the TSM. Thus we can interpret that all of them were at least in the Informational Stage within the Stages of Concerns Model.

> *"… those scenarios are really important and maybe, probably after today, I feel that I will focus more on them." (G4)*
> *"... I have given my normal lessons so many times that I do not think so much of it… but, if I again, after a long time, start to think [about them] more." (G3)*
> *"I have [already] got more than I thought in advance. I am a little ashamed of my bad attitude with which I came this morning, but this has just dawned on me and I'm becoming enthusiastic." (G3)*

We did not analyse the teachers' views according to their school level nor subject, because we used mixed focus groups.

Views related to Scenario

The teachers pondered about challenges to the different interests of students and teachers in their lives as a cause for the design of scenarios, and they also discussed whether they are imaginative enough (this refers to the Personal Stage where teachers are pondering their role). On the other hand, they also felt that teachers should feel themselves comfortable with the scenario.

> *"... I do not even try to be aware of what they are doing in their free time… so if I tried to [plan] what is related to their environment, the world of adults and the young wouldn't necessarily meet." (G7)*

> *"... one needs to use that scenario in the module, but I think that I would somehow adapt [it]… the idea would remain the same, but it would become more personal… closer to a teacher." (G1)*

The teachers acknowledged that scenarios should be natural and relevant for the students (cf. Consequence Stage: relevance to students), but they saw designing that kind of a scenario, which really is connected to the learning theme, challenging (Management Stage). Furthermore, they also perceived that it is problematic to justify the complexity of the scenario: it should be simple enough to limit inquiries to the topic under study (Management Stage).

> *"[T]hat there is some kind of relevance with the issue, which is under teaching: mechanics, electricity, optics." (G2)*

> *"Did we already discuss that [a scenario] should also be somehow outlined that it would be easier to move on to the inquiry phase… that you can catch some point from where to start inquiring."(G6)*

Some teachers saw that teachers should be careful with ethical questions; i.e. no student should feel hurt if the scenario is, e.g., dealing with traffic accidents. Some of the teachers felt that starting by using existing scenarios would be a safe choice.

Views related to Inquiry

The transition from Scenario to Inquiry needs a thorough teacher-led discussion, according to most teachers. The role of teachers was also discussed from the viewpoint of how much teachers could participate, should they give the instructions for inquiries and how detailed should the instructions be. Furthermore, they suggested that teacher should condense the issue at the end of the Inquiry. All the above mentioned views can be classified within the Management Stage.

> *"… the challenge probably is that how to give instructions to students." (G1)*

> *"… a research plan of a sort should be given to students… at least a shorten one… or guided… somehow to combine the theme and practical inquiry… one need to think [things]" (G2)*

> *"[The] traditional way is [to tell] what to do first… and then the teacher quickly summarizes at the end…" (G2)*

In considering Inquiry, the teachers heavily concentrated on content learning and how to test acquisition (cf. Consequence Stage: students' learning), but they did not have actual concerns on conducting the inquiry process itself.

> *"There is, at the end, a discussion with students and one can ask things from students…" – "But does it reveal everyone's knowing?" – "No."(G1)*

”One thing is that we must have tests [anyway], traditional tests. Can we be sure [about students’ knowing] before? Or… if we must teach the things again…” (G3)

Views related to Decision-making

Here the teachers were afraid whether the students had gained the necessary knowledge for decision making and if students should be scaffolded by detailed questions in the decision-making phase; both these concerns refer to Management Stage.

“If the results... if inquiry has been successful and there is enough data and results, conclusions could be drawn… but if you cannot handle that content you are lost in decision-making… [A]t least partly: if you do not have different options then, how you can map decision-making…” (G6)

“I wouldn’t control the transition [phase] from inquiry to decision-making.” (G2)

Some of the teachers noticed that students should go back to the issue set in the scenario and relate decision-making to the scenario; there was also one discussion where two teachers viewed decision making as the same as conclusions in the inquiry process.

”… so, [the students] should learn something during the inquiry and they should then be able to utilize what they have learned in order [to give a] solution to the problem presented in the scenario.” (G5)

”… but here it brings more that [gained knowledge] should, at once, be applied to that problem. I feel that [applying knowledge] is emphasised here.” (G8)

“We should not take [the decision-making] as separate, even if it is said.” – “No, we shouldn’t.” –It somehow belongs to it…” – “It is like result analysis.” – “Yes, it is [that].” – “So, you do measurements, present them and then the most important phase is the conclusions where you can apply that…” – “Yes, that is what it merely seems to be about.” (G2)

Other, more general views

The teachers discussed also Management Stage concerns, like different student groups and scheduling; time resources were especially emphasized. Some teachers also pondered about their own courage to implement TSM.

> *"The most talented and best [students] can pick up the content by themselves... in particular from source materials and especially when they explore in the inquiry phase..." – "Should there then be some hints and extra questions for weaker [students] in guiding their inquiry towards right direction?" G6)*

> *"It takes much time to plan a good scenario..." – "I can [conduct] such a project if I extra hours are given…" (G2)*

> *"[I] could [think to] throw myself into [this]…" – " [This] doesn't seem [to be] terribly difficult… three during one year…" (G3)*

> *"I have not enough courage to… only… create a scenario by myself and then [trust] that students search for more information and apply it… and they learned things just like that…" (G2)*

The teachers expressed interest in sharing implementational experiences (Collaboration Stage) and they believed that shared experiences will help them in developing further implementation of TSM in science classes (Refocusing Stage: initiatives or improving the innovation). A couple of teachers mentioned even a need for a systematic study on their own actions.

> *"Now we have gained [knowledge] how to implement this [TSM] from the students' point of view, but when we start to apply these and everyone [of us] is doing it at slightly different times, I think that it would be very important that we write about own experiences in Moodle. " (G2)*

> *"... discussions in Moodle could be very important… to get critical feedback if you have got an idea and you'd like to start trying it." (G3)*

> *"…if one would like to study by oneself which [way] feels better to teach, the old one or this new approach." (G3)*

CONCLUSIONS

For professional development opportunities, we need to listen to teachers' voices about their views on effective science teaching from idealistic models, e.g., PROFILES philosophy, and realistic perspectives originating from the school context (cf. Fraser, 2010). When compared to the Stages of Concern Model (Hall & Hord, 2011), we recognised that most of the teachers' views were related to managing and organizing the lessons ('management') which shows that they are focusing on the 'Tasks' involved for the innovation. However, there were views which can be classified in the 'Self' and 'Impact' categories, the latter implicating that the teachers were able to consider what kind of impact the TSM could have on their students ('consequence'), to begin to wonder how their colleagues could implement it ('collaboration'), and even to think what kind of action research on their own implementation cycles ('refocusing'). We think that teachers' multiple voices, conceptualised through Stages of Concerns, shows the need and usefulness to listen to teachers in the very early phase of introducing an instructional innovations, like the TSM.

On the other hand, the focus group discussions, prior to the first implementation of the TSM, revealed some crucial points that need our attention. First, we should discuss everyday constraints, like time resources and fulfilling curricular goals. In the study by Valdman, Holbrook & Rannikmäe (2012) teachers who had implemented the three stage modules raised questions related to time resources: the length of time required to teach using the TSM and indicating that the preparation for the teaching modules, for the first occasions, takes a very long time. Time resources came out also in a study (Gray & Bryce, 2006) concerning teachers' views in a summer school course focusing on usage of socio-scientific issues in school. Reason for the image of limited time resources in science class might be caused by the fact that teachers do not see Inquiry as a major science learning stage (cf. Bolte et al., 2012); they might think that they need to teach the content before or after the implementation of TSM. Planning and trying-out teaching modules takes time, of course, during the first implementation, but we think that when teachers recognize their students' gains (cf. Bolte, Keinonen, Mühlenhoff & Sormunen, 2013), they will understand the benefits that TSM bring to their science classes. Curricular concerns, although less raised by Finnish teachers compared with e.g. Estonian teachers (Valdman, Holdbrook & Rannikmäe, 2012), must be discussed with teachers too. Planning TSM-based teaching should start by reviewing curricula and science textbooks and then lead to innovating every-day, student-familiar scenarios that are in line with the science content and skills at the particular school levels.

Second, the teachers need to be encouraged and supported, especially when they are planning both the Scenario and Decision-making. The teachers need also to place more trust in their students' abilities when they proceed from the scenario to the inquiry phase and from there to decision-making: detailed instructions are not needed unless the students ask for them. That might not be easy to accomplish; for instance, in the above mentioned study (Valdman, Holbrook & Rannikmäe, 2012) with teachers who had taught according to the three stage model, 1) they put relatively little faith in student-led teaching for all components of the teaching, and 2) they recognized Decision-making as the presentation of results, collecting feedback and a stage for making summaries. Interestingly, the Finnish sample of teachers did not indicate any concerns related to inquiry-based teaching itself; that might be a consequence of its already accustomed use: both science curricula and textbooks have emphasized inquiry-based teaching since the 1990s (Lampiselkä, Savinainen & Viiri, 2007; Saari & Sormunen, 2007).

In order to promote teachers' beliefs and practices to change, the findings of this study are seen as helping us to understand teachers' learning – how they comprehend the TSM and its use in classroom – and needs for educational change (cf. Simon et al., 2011). The Finnish PROFILES teachers' views on the TSM will be studied in the next project phase, when they have planned and implemented the first TSM-based teaching sequence with their students and then, at the end of the PROFILES programme, when they are more and more experienced with the TSM.

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