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SCIENCE TEACHERS CHANGE TOWARDS STL TEACHING

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Abstract. The paper describes the effectiveness of the intervention training and draws attention to the most important factors to be considered in developing service programmes for the promotion of STL teaching skills. STL is taken to mean developing the ability to creatively utilise sound science knowledge in everyday life to solve problems, make decisions and improve the quality of life. The STL study was divided into three phases: teaching based on STL materials supplied to teachers, a six month active involvement through workshops where teachers developed and tried out their own STL materials and a follow up allowing the application of the skills acquired during the intervention. STL materials were defined as materials, of social issue, based, student-centred decision-making, and/or problem-solving units, within curriculum topics (Holbrook&Rannikmäe, 1997). Altogether, 45 science teachers and 1163 students were involved in the study.

As a result of the 6 months intervention period it was found that the major factor illustrating effectiveness of a teacher developed STL materials was their ownership of STL teaching, expressed in terms of the ability to develop consequence maps. The structure of the consequence maps was used to distinguish three categories of teachers: subject learning activity based, with dominance on facts and concepts; sequenced activity based, with emphasis on process skills; social issue based, including problem-solving and decision-making strategies. Data collected 10 months after the intervention had indicated the need for re-categorisation of teachers, because the extent of the teacher change was not sustained and ownership of STL decreased. Three new categories were found based on teacher's perception of relevance of science education: motivational relevance, skills relevance and social relevance.

The effectiveness of the intervention programme was obvious: teachers who acknowledged the need for teaching social skills in conjunction with science concepts and process skills, continued to embed these ideas into their teaching ten months after the intervention. The sustained change was illustrated by phenomenographical outcome space (Marton, 1981).

Introduction

Change slowly takes place in schools. Many science education projects have been undertaken in the developed world over the last few decades (Yager, 1999; Bell, 1998; Hofstein, 2001) trying to change a perception of science and the rationale for teaching science subjects in schools. But in the majority of countries, science education is being seen, as the transmission of science to students that is perceived as a body of knowledge with little reference to educational gains.

Nowadays, in post-Soviet countries, and especially in Estonia where independence was regained in 1991, the society is changing faster than the educational system. In-service teacher training, being linked to the educational system, is lagging behind. Furthermore, students, as members of society, seem to welcome teaching geared to economic and social development that relates to the situation in their lives, but to lose interest and motivation when it comes to studying science subjects (Rannikmäe, 1998) Science, as a body of knowledge or a particular way of thinking has always been strong in the previous Soviet countries. As Estonia has moved towards embracing Western cultures, especially in social science subjects, curricula with new content have been developed quickly. It is, therefore, more relevant to the younger generation. This has proved less so in science subjects, pointing to difficulties in moving away from the previous strength in science subject matter.

The current paper will focus on solving the following problem areas:
1. Science taught at school seems to be irrelevant for students. Students do not find science useful for their lives and future developments. (Osborne & Collins, 2001; Holbrook, 1998; Sjoberg, 2001)
2. Science education is isolated from the value components of education and communication. Collaborative behavioural (learning) skills are not appreciated as goals of science education. Science education has visually become value free for students. At the same time, the community needs to address more and more moral and ethical issues and related problems (Holbrook, 1998).
3. Over the last 10 years research has shown that the lack of higher order learning among students has inhibited the development of problem-solving and decision-making skills among school graduates (Zoller, 1994)

All the previous concerns are interrelated and can be discussed within two domains: teacher's lack of training to teach higher order thinking skills (problem-solving, decision-making) to students and concerns for the context where the science content is taught by teachers. Besides, it is essential to promote communication skills in a variety of forms, collaboration skills among students and a recognition of skills to form and justify social value. This gives rise to the goal of teaching science as being able to promote scientific and technological literacy (STL) among the students. This is usually taken to mean developing the ability to creatively utilise science knowledge in everyday life: to solve problems, make decisions etc. (Holbrook & Rannikmäe, 1997).

Research projects carried out in Israel and USA emphasise the role of science teachers in educational reforms (Hofstein, 2001; Yager, 1999) to achieve better results in science learning. It is not enough to develop curricula in isolation of the teacher and expect teachers to adopt the intentions, modify teaching materials and redevelop the instructions. The role of the teacher becomes essential for developing student centred teaching and curricula that best fit the needs of the students. It thus goes without saying that it is important to change the attitudes and understanding of all teachers (Yager & Weld, 1999) if meaningful reforms are to take place.

Research methodology and findings

The current study focusses on the teacher's development towards teaching scientific and technological literacy (STL). The goal of the study is to share with teachers the essential attributes that characterise STL teaching and determine whether these attributes continue to be accepted and employed in teaching ten months after the intervention. This study is planned in 3 phases. Phase 1, where twenty teachers were asked to teach, based on supplied teaching materials. Respondents' opinions were collected through open ended interviews and written records (table 1).

Table 1. Teaching based on STL materials supplied to teachers.

1. Most of teachers (16) liked STL materials, because of the group work; only 3 teachers emphasized encouragement of student thinking.
2. 6 teachers were negative towards the use of STL materials as they found assessment difficult and /or interdisciplinary context complicated teaching in traditional way.
3. Most of teachers (12) saw the major goal for science lessons as the development of the subject. Only 4 of them found wider educational goals as the essential ones.
4. Teachers adapted materials using them as the additional information on units for revision of science content.

In phase 2, during a six-month workshop-type intervention, 25 teachers were guided to develop their own STL materials (Holbrook & Rannikmäe, 1996) and pilot these and other exemplary materials in teaching chemistry for 692 10th grade students. Teachers were put into categories based on STL attributes, which were implied in a teacher-constructed consequence map (Rannikmäe, 2001). [A consequence map starts from an issue or concern and shows the implications from a number of different teaching approaches, each leading to its own special science content]. Data were collected through research observations from the intervention workshops, open ended interviews and assesment schemes created by teachers (table 2).

Table 2. Teacher developed STL materials during 6 months intervention study.

1.Teachers stated 3 types of goals for teaching: subject-, general- and social-oriented.
2.10 teachers stated social-oriented goals; 7 teachers stated subject goals only.
3.Less than 20% of the goals were worded in a student-centered way.
4.Student-centred teaching was expressed mainly in terms of doing individual work, such as conducting an experiment.
5.Problem-solving was seen as a subject-oriented activity, often in a question format (20 teachers).
6.The teacher changes in creating teaching materials during the period of intervention were towards greater emphasis on interdisciplinary.
7.Teaching emphasis of only 7 teachers remained unchanged throughout the whole intervention period; 5 of those remained subject-oriented.
8.Recognition of social issues within the development of teaching appeared after 2 or 3 interventions by 12 teachers.
9.By the end of the intervention, 20 teachers created consequence maps that included decision-making; however, 5 teachers did not distinguish between problem solving and decision-making.
10.Teachers created 3 types of scenarios within STL materials – subject-oriented (5 teachers), activity–based (7 teachers) and social-issue related (12 teachers).
11.Pre-intervention assessment schemes performed by teachers gave equal weight to higher and lower order cognitive skills (18 teachers).
12.Post- intervention assessment schemes gave more weight to higher order cognitive skills (12 teachers), 7 teachers gave scores to value judgements.
13.23 teachers recognised the need for setting wider educational goals for science lessons.
14.All teachers expressed a positive attitude towards the use of STL scenarios. All teachers perceived gains in the use of STL criteria in their teaching.
15.Teacher gains, as judged by teachers, were mainly in the areas of pedagogical knowledge (20 teachers and collaborative working (18 teachers).
16. Twenty teachers separated problem-solving from decision-making and 15 showed examples of socially related decision-making activities, which they had used in their teaching.
17.Teacher concerns were applicability of STL teaching within the current curriculum framework (17 teachers), lack of teaching materials (12 teachers) and time consuming process for the development of materials (10 teachers).

In phase 3 no in-service provision, or additional information about STL teaching, was offered after the intervention, although the teachers met twice to communicate and exchange their experience. Ten months after the intervention, data was collected from classroom observations. Each teacher determined which lesson to be observed. Classroom observation was guided by the expected outcomes of the intervention study and the STL teaching philosophy (Holbrook & Rannikmäe, 1997). Classroom observation data was carefully compared to the information collected through an interview with a teacher after the lesson. Teachers were also asked to answer an open-ended questionnaire, which was administered during a seminar (at the end of the school year). A follow up group discussion was also held with all the teachers.

Table 3. Sustained change 10 months later.

1. Problem-solving was strongly emphasised in teaching by 13 teachers; decision–making by 6 teachers.
2. 6 lessons were highly student-centered; 8 lessons lacked a student –centered component.
3. 16 teachers used a scenario or fragments of scenarios in their teaching.
4. Two teachers did not show any attempt to use a STL approach in their teaching.
5. 15 teachers did not utilise an assessment strategy in their lesson.
6. Five teachers indicated they had developed new STL materials following the intervention study.
7. All teachers suggested that STL teaching should be promoted to a wider audience of teachers.
8. Most teachers (17 teachers) saw STL scenarios as tools for increasing motivation of learning science among the students.
9. 4 teachers had forgotten the meaning of socially related scenarios.
10. Teachers had three types of opinions about "relevance " for students: curriculum and examination related (6 teachers), skills related (5 teachers), social issues related (7 teachers)
11. Teachers showed more confusion between problem-solving and decision-making than at the end of the intervention period (11 teachers).
12. Generally, it was recognition of student's achievement by teachers, but only 7 of them recognized they had undergone self-professional development.
13. 12 teachers used assessment strategies directly related to the curriculum: scenarios/socially related issues were used to motivate, not to assess.

13 teachers saw constraints related to covering the content driven curriculum.

Discussion

Teachers' support for teaching which was relevant to students' interests was identified as a key attribute of teacher change towards STL teaching. This support seems to stem from a student-related component and a teacher-related component. The student-related component describes the way the teacher presented the materials to students and skills that were targeted and assessed. The teacher-related component describes the teachers' efforts for self-change towards STL teaching. Student- and teacher-related components were identified from a range of factors. The student-related component included the following factors such as: (a) choice of method used to confirm student-relevant teaching, (b) inclusion of problem-solving activities, (c) inclusion of decision-making activities in a social context, (d) formative assessment practices. The teacher-related component consisted mainly of: (a) the use of a student-centred teaching approach, (b) the way the teacher applied STL ideas, (c) teachers' attitudes towards STL ideas.

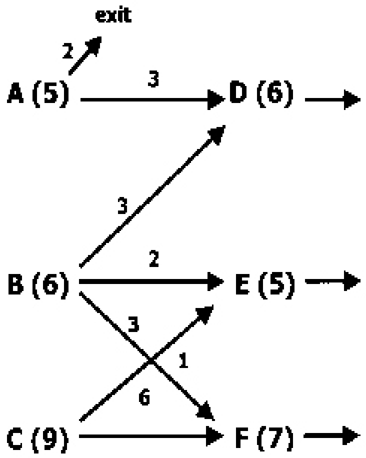
The new categories: D (motivational relevance), E (skills relevance), and F (social relevance) are hierarchical in terms of STL criteria and have a direct relationship with the initial categories: A (subject learning activity based), B (sequenced activity based), and C (social issue based). This relationship is illustrated in Figure 1 representing the outcome space. Figure 1 indicates teachers' transition from one category to another and describes the factors taken into consideration for teachers' re-categorisation. The weighting of each factor (given in brackets in the mathematical relationship) equals the number of teachers described by it.

In Figure 1, the numbers along the arrows represent the number of teachers making that transition. The outcome space is illustrated by two descriptors- students centered and teachers centered, the level of emphasis is given as subscripts l and s.

$$\mathbf{St}\ [\mathbf{R}_l(6) + \mathbf{PS}_l(6) + \mathbf{DM}_l(5)] + \mathbf{Th}\ [\mathbf{S}_{St}(6)]$$

$$\mathbf{St}\ [\mathbf{R}_l(4) + \mathbf{PS}_s(5) + \mathbf{DM}_l(5)] + \mathbf{Th}\ [\mathbf{A}_l(5) + \mathbf{S}_{St}(5) + \mathbf{C}_l(5)]$$

$$\mathbf{St}\ [\mathbf{R}_l(4) + \mathbf{R}_s(3) + \mathbf{PS}_s(7) + \mathbf{DM}_s(6) + \mathbf{A}_s(4)] + \mathbf{Th}\ [\mathbf{A}_s(6) + \mathbf{S}_{St+Th}(7) + \mathbf{C}_s(5)]$$



Emphasis of STL teaching: l = low, s = strong
St – student related descriptor
R – method of confirming relevance to students
PS – problem-solving
DM – decision making
As – assessment

Th – teacher related descriptor
A – student centred approach
S – perception of STL idea applicability (subscript St good for students, subscript Th essential for teacher development)
C – attitude towards STL idea

Figure 1. Outcome space of categories illustrating teacher's sustained change

Conclusions

Teachers are strongly influenced by their perception that science teaching is very different from that in social science and facts and concepts need to dominate over issues relevant to everyday life. Teacher willingness to begin teaching from a social perspective is limited to those who recognise its relevance value. As was the case with problem-solving and decision-making, it would appear that some science teachers find it difficult to understand the meaning of social issues. Only teachers described by categories C/F perceived STL teaching as involving social decision making issues and the identification of values as part of teaching. It is not easy to change teachers' perceptions of science teaching, especially towards the inclusion of social components interrelated with, and aiding the acquisition of, conceptual science.

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Резюме

ПРОЦЕСС ФОРМИРОВАНИЯ ПРОФЕССИОНАЛЬНОЙ КОМПЕТЕНТНОСТИ УЧИТЕЛЕЙ ЕСТЕСТВЕННОНАУЧНЫХ ДИСЦИПЛИН ДЛЯ ПРЕПОДАВАНИЯ ЕСТЕСТВЕННО-НАУЧНО-ТЕХНИЧЕСКОЙ ГРАМОТНОСТИ (ЕТГ) СРЕДИ УЧАЩИХСЯ

Миа Ранникмае

В работе описывается эффективность курсов подготовки учителей и выявляются наиболее важные факторы, которые следует учитывать при разработке программ подготовки будущих учителей для повышения их умений обучения научно-технологической грамотности (STL). Под STL понимается способность повседневного творческого применения научных знаний для решения проблем, принятия решений и улучшения качества жизни. Изучение STL было разделено на 3 стадии: 1) обучение учителей на основе розданных им материалов; 2) 6-месячное семинарское погружение, в течение которых учителя сами разрабатывали и опробовали STL-материалы; 3) продолжение, в течение которого учителя применяли полученные умения. STS-материалы построены на общественных проблемах, самостоятельном принятии решений учащимися и/или проблемных модулях в рамках программы (Holbrook & Rannikmae, 1997). В исследовании участвовали 45 учителей естественнонаучных предметов и 1163 учащихся.

Найдено, что главным фактором – показателем эффективности разработанных учителем материалов – является его авторский стиль, выражающийся в способности разрабатывать карты последовательности. Структура этих карт позволила выявить 3 категории учителей: 1) деятельность которых основана на изучении предмета с упором на факты и теории; 2) деятельность которых основана на развитии умений последовательного осмысления процессов; 3) деятельность которых основана на общественных проблемах, включая стратегии решения проблем и принятия решений. Эти три новые категории были определены на основании учительского восприятия необходимости естественнонаучного образования: мотивационная, навыковая и общественная необходимость. Однако данные, полученные на протяжении 10 месяцев после курсов, заставляют пересмотреть распределение по этим категориям, поскольку степень изменений учителей не соблюдалась и авторский стиль STL-материалов падал.

Эффективность программы курсов была очевидна: учителя, признающие необходимость преподавания общественных умений в связи с научными теориями и процессуальными навыками, продолжали проводить эти идеи и через 10 месяцев после окончания курсов. Целенаправленные изменения иллюстрировались феноменографическими полями результата (Marton, 1981).
Ключевые слова: естественнонаучное образование, профессиональная компетентность, естественнонаучная грамотность.

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