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Identifying Estonian Stakeholder Views as the Bases for Designing Science Teachers' in-Service Course which Support Promotion of Competence Based Curriculum Goals

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ABSTRACT: This study solicits views about the goals of science education from a range of stakeholders within the science education community and society. It also compares students' needs, expressed through stakeholder expectations, with the current learning situation of gymnasium graduates. The study uses a Delphi method to solicit views with 111 participants in the 1st round, 103 participants in a 2nd round and 84 participants in a 3rd, consolidating round. The results revealed significant gaps between the expectations of all investigated groups and the actual realisation of levels of obtained competences by students at secondary school leading to five crucial competence areas needed for future employees: personal attributes, academic skills, creativity, communication skills and scientific knowledge.

KEY WORDS: Stakeholders, Science education, Future citizenship, Competence-based curriculum, Competence-based in-service course

INTRODUCTION

Research has shown that there are gaps between students' wishes and how school science has been taught, as well as gaps between employees' opinions and school science education goals (Choi *et al*., 2011). A key message in education is the need to re-imagine science education to suit today's world, as students require a new skill set which goes beyond acquiring textbook framed science knowledge. It is the mission of education to adequately supply students, not only with factual knowledge and domain-specific problem solving strategies, but also with a broader

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set of skills required in today's societies which are particularly relevant for successful educational, professional, and personal development in the 21st century (Greiff *et al*., 2014).

Estonia introduced a new competence-based curriculum in 2011, intended to initiate a paradigm shift from memorization of knowledge to transferable skills, focusing strongly on developing so called new life skills as problem solving, decision making, reasoning, communication skills, creative thinking skills etc. According to recent project results, students agree that some skills are promoted in science subjects, while others are not – it seems that the teaching of science subjects promote single skills as part of problem solving and decision making, but the focus on the problem solving or decision making as a whole are not promoted enough. Students, studying at the gymnasium level, indicate the importance of these skills in their future career (Soobard & Rannikmäe, 2014). In international discussions a key question is how teachers themselves learn analytical and critical thinking skills and how they achieve competence and knowledge-creation skills. That's why it is important to offer to science teachers specially designed in-service course with contents that are in accordance with stakeholders' expectations.

The goal of the current study is to solicit stakeholder views to form a base for design an in-service course for teachers to realise new, relevance and competence-based curriculum outcomes. The current study posed four research questions: (1) How does the current state of science education fulfil the expectations of the science education community and society? (2) Are the learning outputs of the new science curriculum in accordance with the expectations of different stakeholders? (3) What are crucial components in designing an in-service course for science teachers to address gaps between the importance and realisation of graduating students' competences?

THEORETICAL BACKGROUND

With the emergence of increased attention to competences required by citizens for a knowledge-based society, schools and educational systems around the world have been called upon to make changes to their curricula (Greiff *et al*., 2014). Success in school reforms depends on societal support and needs to be based on the recognition of the importance of studying the understanding and attitudes towards science and technology (Besley, 2013).

The Partnership for 21st Century Skills identified new generation student outcomes and skills. Among those skills, the 4Cs (Critical thinking and problem solving, Communication, Collaboration, and

Creativity and innovation) are seen as core skills for students to be successful in the future (Eguchi, 2014). A more international challenge put forward by the European Union, identified as Responsible Research & Innovation (Cavas, 2015), addresses the fact that societal actors, such as different stakeholders (researchers, citizens, policy makers, business, third section organisations, etc.), are expected to work cooperatively to meet society's expectation, values and needs in the field of science and technology education and research.

Citizenship development and the role of education have been increasingly discussed by educators, politicians and researchers over the past decades. This includes the teacher's role to support students to be active, responsible and socially engaged citizens. Many teachers have not received any training to teach citizenship education and, as a consequence, they do not feel confident about teaching it. Currently, teachers' education and training are worldwide considered crucial for every country with globalized and knowledge-based economy. Equipping citizens to deal with these demands requires a new model of education and training, a model for lifelong learning (Aleandri & Refrigeri, 2014).

Using a Delphi study to solicit stakeholder views

During recent years, several European Commission funded projects have focused on exploring types of support stakeholders offer to science education. Under the PROFILES project (Bolte *et al*., 2012), a Delphi curricular study was carried out involving stakeholders from science and the science education community and focusing on the content taught in science classes and contexts to include in the curriculum.

A Delphi study is particularly helpful when a domain does not lend itself to analytical techniques, but can be better estimated by group judgement. The aim is not to achieve consensus among stakeholders' panel, but to facilitate a structured and systematic group communication process. The method is usually applied in several rounds or stages where the number of rounds can vary, although there is general agreement that at least two rounds are required (Linstone & Turoff, 2011).

RESEARCH METHODOLOGY

Sample

Table 1 shows the sample participants for the three rounds consisted of 111, 103 and 84 participants respectively from 6 different stakeholder groups. The drop in numbers across rounds was because one of the inevitable drop-out of participants during the study.

Table 1. The sample of the Delphi study

Group	Participants of the study		
	1st round (N)	**2nd round** (N)	**3rd round** (N)
Secondary school students	20	19	13
Science teachers	18	16	15
Science educators	16	15	10
Pre-service science students	14	13	13
Scientists	15	14	13
Employers	28	26	20
Total	**111**	**103**	**84**

Instruments

1st round. In the first, the Delphi study instrument consisted of two open-ended questions for which the participants were asked to give their opinions. These open-ended questions focused on: (1) the preferred knowledge and skills the students are expected to possess when they enter the labour market and/or society after completing secondary school; (2) an evaluation of the current state of science education in Estonian gymnasium schools from the competence-based curriculum perspective; suggestions for improving the science education/scientific literacy of students.

2nd round. For the 2nd round, a 55 item 6-point Likert-type questionnaire was compiled, based on the 5 competence areas created against 1st round responses: personal attributes, academic skills, creativity, communication skills and scientific knowledge. All responses were organised in two columns labelled as the importance of expected skills in a future career and the current realization of science education at school.

3rd round. The intention of the 3rd round questionnaire was consolidating the stakeholders' opinions in the five competence areas against the descriptions of these competence areas (Table 2). The respondents of the 3rd round were asked to assess the importance and the realisation of these 5 areas of competences on a 6-point scale and they were also asked to offer the possible ways to improve the studies at secondary school to raise the image and popularity of science in open-ended question form.

RESULTS AND ANALYSIS

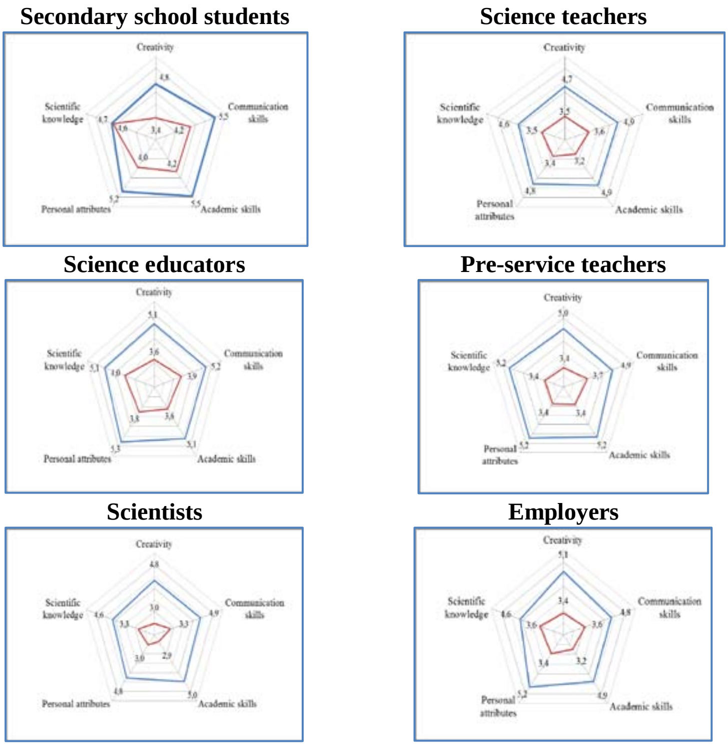
1st round. The more frequent responses were divided into 5 competence areas as indicated in table 2. For all groups of stakeholders, there were large gaps between the importance of expected competences of future citizens and the realisation of these competences at higher secondary school (Post *et al*., 2011).

Table 2. The description of derived competence areas mentioned by stakeholders

Competence area	The context of the area	Examples
Academic skills	The so called new generation transferable skills needed in future life and career.	Problem solving, decision making, argumentation skills, reasoning, inquiry skills, planning skills, *etc.*
Scientific knowledge	The core science knowledge isolated from transferable skills.	The basic knowledge of biology, earth science, chemistry and physics, mathematics and informatics.
Personal attributes	Personal attributes that are crucial for nowadays workforce.	Responsibility, independence, imitativeness, punctuality/meeting deadlines, tolerance, adaptability *etc.*
Communication skills	Communication and collaboration skills needed for cooperation in society.	Oral, written and graphical self-expression, readiness for collaboration and cooperation *etc.*
Creativity	Creative thinking skills which enables divergent thinking and results in innovation.	Flexibility, openness to new ideas, ability to see different perspectives, originality of ideas *etc.*

2nd round. The results of the 2nd round gave the detailed profiles of investigated opinions of science and society related stakeholders about the expected and current status of science education (Figure 1). The overall results show that all groups of stakeholders value the different competence areas very highly: from a mean of 4,73 (scientific knowledge) to 5,17 (academic skills). The realisation of three of the five competences (creativity, academic skills and personal attributes) was below average and the highest evaluation (3,82) was realisation of scientific knowledge.

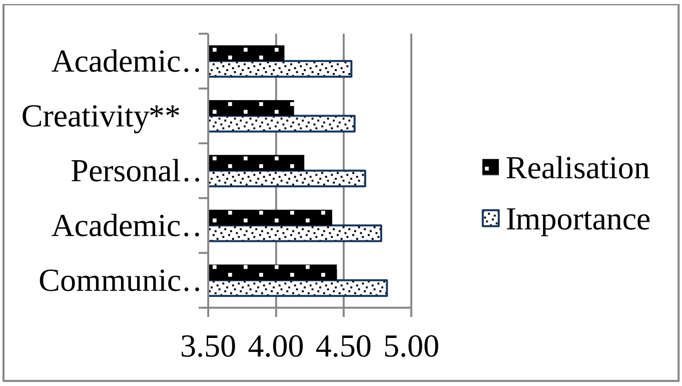
An analysis of the results indicate that the most similar groups according to their profile of opinions are the science teachers, science educators and pre-service teachers who have received similar pedagogical training. Based on this, it can be concluded that those most satisfied with the appropriate description of competences are the secondary school students and they are also the most satisfied group with the actual realisation in all areas of competences. The scientists and employers, as representatives of society, are in accordance valuing all areas of competences, except scientific knowledge. The statistical analysis (Kruskal Wallis test) showed that all stakeholder groups' opinions were varied statistically significantly about the realisation of competences but their opinions about importance differed significantly only in two areas of competences (scientific knowledge and academic skills). The meaningful differences occurred between the opinions about the expectations and realisation of all competences within all groups of stakeholders, except the students' perceptions about the scientific knowledge, showing that none are satisfied with the state of learning outcomes of science education at the gymnasium level.



Inner line – the realisation of the mean levels of competences;
Outer line – the mean levels of importance of competences at school.

Figure 1. An analysis of the results of the 2nd round of Delphi study, showing the profiles of different interest groups' opinions about competences.

3rd round. The results of the 3rd round of consolidation (Figure 2) reveal that all four groups of stakeholders, on average, valued the importance of all five areas of competences significantly higher than the realisation of them at school (for all the paired samples, T-test $p < 0,000$). The stakeholders valued the importance of competences quite similarly, assessing the scientific knowledge the lowest and academic skills the highest competence area. The 3rd round consolidation results suggest that the expectations for future career are focused mostly on acquiring academic skills and highlight the importance of personal attributes and communication skills. Less emphasis is put on achieving scientific knowledge (especially from the employers' side) which is present in the current education system at the highest level, compared to the needed competences for future careers.



*Significant difference between the groups at the 0,05 level of confidence
** Significant difference between the groups at the 0,01 level of confidence

Figure 2. The comparison of mean results of the 3rd round of Delphi study, evaluating the opinions of the different stakeholder groups about the importance and realisation of the competence areas.

The course included four 2-days blocks and focused on four areas of competences most appreciated by stakeholders: the integrative science knowledge, the academic skills, the communication and the creative thinking skills. As the development of students' personal attributes is an ongoing and recurrent goal of general education and is considered in learning process permanently, it was not covered within this course separately. To promote teachers communication skills, all teachers worked together in all activities in the groups of 4–5 different science subject teachers, preferably in the teams of the same schools. Every group of teachers designed and planned the competence-based activities on their selves chosen relevant socio-scientific issue. The teaching materials were created in the everyday context with social and scientific components enabling the students to transfer their knowledge and skills into new situations.

The teachers' feedback (in the form of 5 items open-ended questionnaire) to the enrolled in-service course was very positive, mostly because of the possibility for actual designing the learning activities and practicing themselves the different competences, increasing their own communication skills and creativity. All 30 participating teachers admitted that their abilities and self-confidence in fostering students' competences, appreciated by different stakeholders, increased considerably during the in-service course. Most of the teachers (28 of 30) reported the readiness to continue the cooperation with colleagues to implement the new competence-based curriculum more thoroughly.

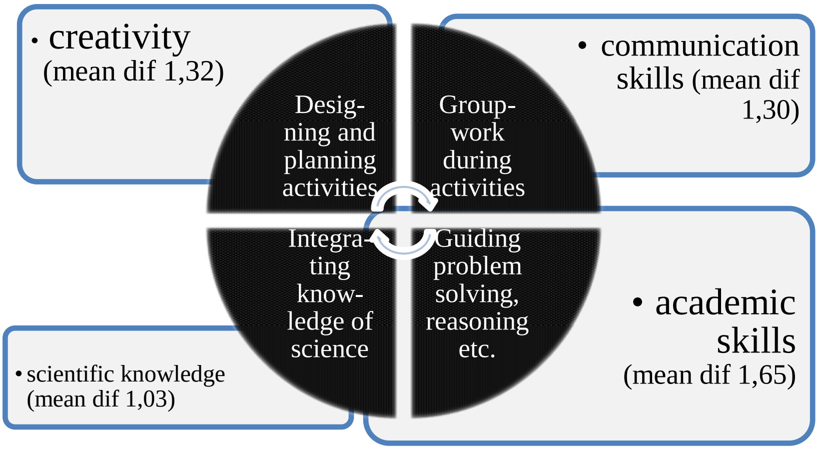


Figure 3. The design of science teachers' in-service course for fostering the consolidated competences of re-imagined future citizens in the line with expectations of stakeholders and new science curriculum.

Discussion And Conclusion

Based on Delphi study outcomes the main problem of science education in Estonia is the need to provide support for teachers in implementing competence- and competence-based science education in order to fulfil the expectations of society for future true competent citizens. These radical changes towards newly structured capabilities of graduating students can be realised only by their teachers' renewed paradigm of education with the support of solidary stakeholders in society.

All groups in this study admitted there are considerable gaps between the ideal expectations and actual realisation of the achievements in science education. The smallest gaps between importance and realisation of useful competences for scientific literacy of the future workforce occur with the secondary school students. This indicates that the demands of new curriculum are not sufficiently implicated in students' everyday school life, although they validate the need for academic skills most.

The students' opinions about the realisation of scientific knowledge, communication skills and academic skills were significantly higher than those of all other stakeholders' groups while even practising science teachers have changed the priority of scientific knowledge against academic skills, following the new curriculum. The other two groups of science education community (science educators and pre-service teachers) follow the similar pattern at slightly different levels, valuing the importance of personal attributes and communication skills of students more than scientific knowledge.

The group of scientists is the most sceptical about the current state of Estonian science education at school, especially the low level of students' academic skills. Also the level of students' creative thinking skills do not satisfy their expectations, as they recognise the lack of potential for an innovative knowledge-based society.

The group of employers are of the same opinion regarding to the insufficient level of the development of academic skills and creativity at school science, but they differ from scientists in expecting higher personal attributes for future employees, as well as with science educators who both share the understanding that personality attributes are agreed to be valid predictors of success in education and job performance. These results are in line with international trends, indicating that (1) school science does not meet the needs for promoting 21st century skills (Besley, 2013) and (2) the focus of science education should be more vigorously pointed towards developing the before-mentioned 21st century skills: problem solving and decision making; creativity and innovation skills; communication skills and integrated scientific knowledge.

The learning goals of the new science curriculum are actually in accordance with the expectations of different stakeholders, especially for scientists and employees. In this, they focus on students' creativity, academic and communication skills plus personal attributes for an innovative and knowledge-based society, as declared in most science education communities (Bolte *et al*., 2012). However, there is still a gap between the expectations and realisations of stakeholders needs, but fortunately, the education community has started to realise this and implement new curricula in the context of 21st century skills.

The results of current study associate with international studies (Choi *et al*., 2011) and show that the actual state of Estonian science education, considering the future needs of the labour market, do not fulfil the expectations of students and educators and even less, the needs expressed by scientists and employers.

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