Science Education International
Vol.22, No.3, September 2011, 202-217

Stakeholder views on attributes of scientific literacy important for future citizens and employees - a Delphi study

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Abstract
This study is based on the creation of a theoretical tool for determining competencies and knowledge in science education which stakeholders value as necessary for students to become productive members of the future work force as well as responsible citizens. Stakeholders' opinions (N=85) were gathered from persons in different walks of life by means of a Delphi study, conducted in two rounds, while a second part of this study set out to evaluate whether the Delphi method is effective in achieving the aim of the study. Results from the first round indicate that stakeholders expect future employees to possess higher levels of scientific literacy, although this is far from being unanimous. This is confirmed in the second round where views held by stakeholders were found to be in line with those expressed in the science literature. The article indicates that Delphi study approaches have merits, but steps are required to avoid typical difficulties such as contacting participants and then keeping theme motivated throughout the research process and in overcoming obstacles which arise. Results from this study are important for both curricular and national development where the goal is to move towards a more knowledge-based society.

Keywords: Delphi study, science education, scientific literacy, stakeholders

Introduction

The present situation in science education reflects a concern: the European Commission report (2004) states that students' attitude towards science is poor while outcomes from the PISA2006 study showed science was not an interesting subject in many countries (OECD, 2007). This relates to previous research which has shown that students are not interested in science as well as not wanting to associate their future career with science (Osborne et al., 2003). This supports the Estonian Research, Design and Innovation strategy document 2007-2013 "Knowledge-based Estonia" which states that the biggest weaknesses in becoming a competitive country in Europe and the world are the small number of graduates in natural sciences and technology (this may be caused by the negative attitudes towards science) plus the lack of attention paid to research and innovation. Yet little is known whether this situation derives from attitudes of the society, students' interests in their future aspirations, or the type of curriculum being promoted in schools. Of particular interest in this respect is the range of stakeholder views on what educators, employers and the like are wishing students to gain from studies in science education.

Scientific literacy

The current situation in Estonia is well highlighted (OECD, 2007; Henno et al., 2008): students' theoretical knowledge in science is above the OECD average, but there is a general lack of inquiry skills and the ability to use knowledge which directly impacts on students' scientific literacy. These findings are quite similar to those found in general by Bybee and Fuchs (2006) and in line with scientific literacy achievements (Laugksch, 2000). To achieve greater economic competitiveness between countries indicates the need for scientific excellence and technological innovation, as well as a strong research and development base (EU, 2004); students need to be provided with the appropriate skills and knowledge for achieving higher levels of scientific and technological literacy.

Many researchers have stated that scientific literacy should be the goal of science education (e.g. Laugksch, 2000; Fensham, 2004; Holbrook & Rannikmae, 2007) and there is a need for a scientifically literate workforce and citizens (DeBoer, 2000; Collins et al., 2001; Fensham, 2004; Brown, Reveles & Kelly, 2005; Bybee & Fuchs, 2006). Gauld (2005) even went as far as to suggest science has an impact on everyone in some way and many scientific issues become political in nature. Whatever the reason, it seems that while future societies need people who are able to use scientific knowledge to solve problems in everyday-life or work situations, schooling is not providing society with sufficient people who have such abilities.

The gaining of scientific literacy can be expressed by using hierarchical levels (Bybee, 1997). This recognizes that scientific literacy is not simply factual knowledge and by use of the levels it is possible to demonstrate a persons' ability to utilize scientific knowledge when solving upcoming problems. Bybee suggested that the first level, which he called nominal scientific literacy, is illustrated by a person who recognizes when a term, question or topic is scientific in its nature, but, however, demonstrates clear misunderstanding. An individual's understanding is minimal in comparison to the accepted scientific understanding for the individual's age and situation.

Bybee termed the second level 'functional scientific literacy.' At this level a person is able to use scientific and technological vocabulary in a particular activity when needed (e.g. defining terms in a test, reading a newspaper, or listening to a television program), but it is generally out of context and lacks the conceptual embellishment of disciplines. Unfortunately, functional scientific literacy has been the ultimate goal of science education for a long time and much emphasis has been placed on attaining this level. This finding is supported by Osborne and Dillon (2008) who claim that science teachers' pedagogy is still dominated by a focus on content rather than developing the understanding of science.

The third level, conceptual and procedural scientific literacy, describes persons who have developed an understanding of the way conceptual parts of a discipline relate to the whole and how scientific disciplines relate to each other. They possess procedural knowledge and skills (e.g. scientific inquiry skills, technological skills, ability to make observations and hypothesis, developing new knowledge using evidence, logic and creativity). In Shen's (1975) words, it can be described as the level of scientific ability which enables the solving of practical problems.

The highest level, multi-dimensional scientific literacy, illustrates persons who have an understanding of science which extends beyond the concepts of scientific disciplines and procedures of scientific investigation. More specifically, such persons are able to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society. In other words, science education has promoted a broader view of science, while simultaneously helping to foster an appreciation for science and its usefulness to society (Roberts, 2007).

Clearly, as Bybee suggests, the multi-dimensional level is seen as a key target for science education. Such scientific literacy, gained through science education, enables the creative use of sound scientific knowledge in everyday life or in a career, to solve problems, make decisions and hence improve the quality of life (Holbrook & Rannikmae, 2009). In this view, scientific literacy is important for both a personal and professional life. It also highlights that besides the capability for problem solving, enhancing scientific literacy also enables a person to improve one's life. In other words, it is associated with the capability to transfer knowledge, skills, attitudes and values to unknown situations such as showing initiative, thinking critically or reasoning oneself in a collaborative working situation.

In order to promote multi-dimensional literacy, it is important to determine from where the impetus to promote such a development is more likely to come. Teachers perceive themselves as confined by the curriculum and curriculum goals and students and society in general seem to be accepting the current school situation. One option is to seek views from a range of stakeholders, or experts without references to school and school science teaching. This can be undertaken by focusing on careers after school and what is perceived as important from that perspective.

Knowledge and Competencies

Both the terms knowledge and competency have multiple meanings and are difficult to express with precision in everyday language. This makes it difficult to seek opinions from stakeholders and then interpret them in a meaningful way. In this article, knowledge is taken to refer to a range of cognitive attributes from factual recall of information to higher level analytical or evaluative abilities. On the other hand, competencies are taken to represent a set of mental capabilities, or skills, attitudes and values which students need to acquire to progress towards the capability to meet curriculum competence standards, set within a particular domain (Gilmer, Sherdan, Oosterhof, Rohani & Rouby, 2011). Fensham (2007) goes further and suggests that competencies are abilities to put elements from one knowledge system together with elements from another, arranging them so that they work in new ways and do new things. In other words, competencies gained in science classes involve, for example, reasoning with evidence and argumentation (Brickhouse, 2007), while competencies, taken from a more general educational view, are the capabilities, expressed as learning outcomes, that will be increasingly needed (Fensham, 2007). It is clear that messages from employers and policy makers, indicating employment competencies that young people should possess, regardless of their relative success in formal academic education, are important for today's personal, social and economic life (OECD, 2000).

Competencies play an important focus in the new Estonian curriculum for gymnasium level (2011) where it is describes as follows: competency is a combination of pertinent knowledge, skills and attitudes which enable to be successful in a particular field of activity. Science education in the new curriculum indicates the need to promote competencies such as understanding relationships between humans-nature-environment, being able to pose research questions and participating in conversations about different scientific fields. While these competencies, also emphasized in reports by the EC (2006) and Eurydice (2009), are seen as important, it is clearly desirable that the value of these competencies are recognized by society and especially by employers and other stakeholders. This suggests that the need for promoting science related careers and also the scientific literacy level of future members of society requires consideration of stakeholder's views and strong compatibility between these views and the competencies being promoted in the science curriculum.

The Delphi method involving stakeholders

A stakeholder or expert is someone who will be directly affected, or has an applicable specialty, or relevant experience (Scheele, 2002). Stakeholders or experts in this particular context are those who hold wide competency-based views on science education goals or have a direct interest in the outcomes of Estonian science education. A major reason to consider stakeholders' views is that whatever change is contemplated, it is more likely to happen when people whose thoughts 'matter more' are involved and actions take the desired course. Stakeholders or experts can also be those who provide employment to future citizens and thus know the directional trends in which the society and its needs are moving, or the kind of competencies or knowledge which is valued in a competency-based society where scientific excellence and technological innovation is the key to success. A consolidation of participants' opinions enables identification of the diversity of expectations from stakeholders, which can then be compared with the familiar goals of science education. Based on this, it is important to disseminate such views to those who directly decide how science should be taught in science classes. Informed stakeholders in a particular field related to student needs and using their informed knowledge and a cultivated sense of relevance are best able to carry out reasoned predictions in his field (Pollard & Pollard, 2004).

One method that is widely used to collect the views and obtain a consensus from a range of stakeholders or experts is the Delphi method (also Delphi study, Delphi technique or simply Delphi) (Pollard & Pollard, 2004; Skulmoski, Hartman & Krahn, 2007). The method itself was introduced in 1950 with the aim to determine national security risks, but later gained popularity in other fields, including research in education (Chypert & Grant, 1970; Listone & Turoff, 2002; Pollard & Pollard, 2004). The Delphi method is an iterative process used to collect and distil the judgments, views or thoughts of experts using a series of questionnaires or questions, interspersed with feedback. The method is usually undertaken in several rounds or stages, where the number of rounds varies. In most cases it is considered necessary to introduce at least two rounds (Pollard & Pollard, 2004; Collins et al., 2001; Skulmoski et al., 2007), where each subsequent instrument is developed based on the results of the previous one. The process stops when consensus is reached, or when sufficient information has been exchanged (Listone & Turoff, 2002).

The main reason for using a Delphi study in this study is to collect information or views from a wide range of stakeholders or experts and at the same time make stakeholders aware of potentially useful views coming from others. The aspect of interest is then to determine the degree of consensus between the stakeholders involved. Although this method has its advantages, there are also disadvantages or weaknesses which can inhibit the effectiveness of the process. The following table (Table 1) illustrates the main disadvantages of using the Delphi method for this study and the precautionary steps taken to avoid or minimize these disadvantages.

The aim of this study is to seek different stockholder's opinions about the competencies and knowledge to be gained from science education, which a school leaver should have in order to be successful in the workforce and/or as a citizen in society. The methodology for seeking stakeholder's views about science education is described in terms of levels of scientific literacy (Bybee, 1997). Based on this, a scale of scientific literacy levels is created which is intended to reflect stakeholders' opinions.

Table 1. Steps taken to avoid the main limitations of using the Delphi method

The limitations of using the Delphi method*	Precautionary steps to minimize limitations
The process is time-consuming and thus participants need to have sufficient time for participation.	The participants were informed of the nature of the study and asked whether they have enough time before the study was launched.
The selection process of experts or stakeholders (experts should be able to answer the research questions) is a critical part because the participants' opinions are crucial.	The selection process was carried out with others from the field of science education. A total of 4 persons were included in the selection of participants.
Researchers influence on the response due to a particular question formulation.	The research question was piloted and validated by others in the field of science education.

*Pollard & Pollard, 2004; Murray & Hammons, 1995; Skulmoski et al., 2007; Listone & Turoff, 2002.

The study is based on the following research questions:

1. What competencies and knowledge do stakeholders hold with the respect to the development of science education and how can these views be interpreted in the light of the need for students to attain scientific literacy?
2. How appropriate is the Delphi study approach in meeting the aim of this study?

Methodology of Research

Study design and sample

In this study, two rounds were used to collect data as illustrated in figure 1.

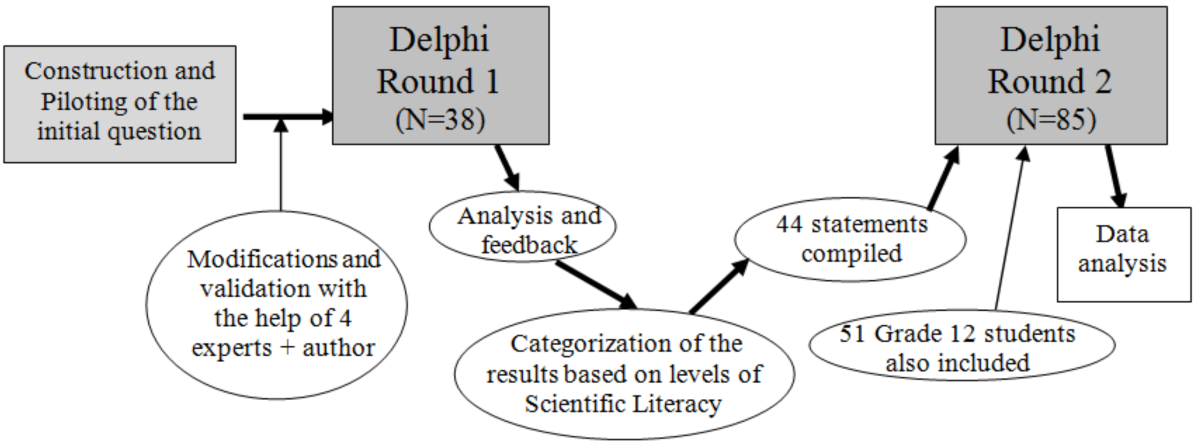

Figure 1. The design of the study.

The aim of the round one open-ended question ("What kind of knowledge and competencies in science education do you expect an individual to possess when he or she enters the labor market and/or society?") was to find out, with the respect to science education, participants expectations for individuals to possess when they enter the labor market and/or society. This open ended question was first piloted with a small number of individuals randomly chosen, with the aim of finding out the main obstacles in using a Delphi study as a method and to gain an indicator of types of problems and answers which were likely to be given. The feedback obtained, as well as a carefully conducted validation exercise using 4 experts, was used to modify the question for the first round to that quoted above.

The selection of stakeholders was based on the fact that all had expertise in the process and practices related to their field of activity which could be connected to the outcomes of science education. The selection process ensured that both the private and public sectors were covered as well as scientists from the natural and social sciences. Participants selected for the study (approximately equal numbers per category, see table 2), were first informed of the nature of the study and asked whether they were willing to participate. In total, 38 stakeholders agreed to participate.

Table 2. Number of participants involved in the study given in 6 categories.

	Public sector employers	Private sector employers	Scientists	Science teachers	Students studying aboard	12^{th} grade students	**Total (N)**
Round 1	8	6	8	7	3	6	38
Round 2	8	6	5	6	3	57	85

The teachers selected for the study were all science teachers teaching in secondary level and thus represented the current direction of science education in school. Insofar as was possible, Estonian students studying in colleges around Europe were also included as they were perceived as having experience within another system and could be able to give opinions about science lessons from another perspective. Students from grade 12 were also included in the study because, after graduating, their knowledge and skills would be needed in society. For the first round, all the 12^{th} grade students were studying in the same class.

After piloting, the first round of the study was carried out as follows: all participants received an e-mail including the round one question and were asked to respond to the e-mail by writing their own opinons in response to that question. None of the participants had previous experience with a Delphi study.

After the first round was completed, the responses were analyzed, categorized, checked by two experts in the field and then reformulated as statements in a 5 point Likert scale questionnaire. These statements (44 in total) were then also categorized by experts (2 experts from the field of science education knowledgeable in the scientific literacy literature working independently and then agreeing to categories by consensus) into the 4 levels of scientific literacy suggested by Bybee (1997).

The 44 statements, in a 5 point Likert scale questionnaire (ranging from 1 being not important at all to 5 being very important), were sent to the participants as round two of the Delphi study so as to determine their opinions about the competencies and knowledge that had been identified in round 1 from all responses. The stakeholders were asked to indicate the importance of each statement with respect to science teaching. The stakeholders were the same as in round one, although 4 participants (1 teacher and 3 scientists) withdrew. Although this might have affected the results, it was recognized that the minimum number of participants to obtain meaningful data is considered to be ten (Pollard & Pollard, 2004). However, in order to get wider, more comprehensive views from school leavers, the number of 12^{th} grade students involved was increased by including an additional 51 students (total 12^{th} grade students = 57). This was considered important because it enabled a comparison of views gained from stakeholders with the views of students soon to enter the workforce.

Results and findings

Results and findings from round one

These results are based on the replies from the 38 participants answering the initial central question "What kind of knowledge and competencies in science education do you expect individuals to possess when they enter the labor market and/or society?" The results showed that there is a strong consensus among different stakeholders about what kind of knowledge and competencies was essential, although stakeholders emphasized the importance of competencies in different fields or subjects, especially in science. But at the same time, it was noticeable that an emphasis was placed on gaining knowledge rather than the use of knowledge. In this respect, the results clearly illustrated the current situation in school, where studies have shown that students possess good knowledge, but they do not know how to use it (Henno et al. 2008).

Without an awareness of the term scientific literacy, many participants emphasized competencies used when talking about a scientifically literate person. Yet from an analysis of the 12th grade student's answers, it became clear that they only emphasized knowledge gained from school and did not see the need for knowledge and skills gained outside of school. Students' answers included more of the elements of school science topics, although they still emphasized practical skills considered important in their future life. Science teachers, as well as students, emphasized more than other groups the importance of factual knowledge gained in science classes. Also, compared to participants from the private and public sector, who emphasized the importance of practical knowledge, teachers still thought it was more important to know laws and facts instead of the ability to use knowledge.

Based on the responses from the first round, individual statements, covering the separate points made, were compiled into groups according to similarities of themes. The essential competencies, skills and knowledge from these groups were then put into one statement to comprise the 44 statements.

Results and findings of round two

An analysis of the 44 statements showed that none could be assigned to the first level of scientific literacy (see table 3) and hence the first level was not considered further.

Results were obtained from 85 respondents and analyzed as shown in table 4. Responses from the 44 statements were included for each group where (a) an overall mean value was 4.00 or higher and (b) the mean value was 3.00 or lower. The main reason for this selection was because stakeholders had already given their opinions on the original research question and thus these statements represented areas of relative importance, or non-importance for them. This group selection process omitted those statements for which the emphasis was not so apparent. All statements included in the questionnaire are given in appendix 1 together with the identified science literacy category level.

The number of statements, with mean values 4.00 or above, or 3.00 or below, for the six groups is indicated in table 4. The actual statements are given in appendix 1.

Table 4. The division of statements between the levels of scientific literacy among 6 study groups, given as number of statements and a percentage of the total statements at that level

Table 3. The division of statements between the levels of Scientific Literacy (SL).

Levels of SL	Description of the level	Number /(%) of statements (N=44)	Examples of statements
2nd level-functional	Is able to use scientific vocabulary when needed; memorize and reproduce scientific knowledge; knowing what has been taught in school	17(36%)	*ability to memorize and reproduce facts and formulas taught in school* (statement 16)
3rd level-conceptual and procedural	Is able to use knowledge and skills from science and technology, logic, observational and inquiry skills when solving problems in work and home and cooperate with other people	20(48%)	*ability to recognize science content in everyday life issues* (statement 41)*;* *ability to examine/observe processes or phenomena in the nature* (statement 2)
4th level-multidimensional	Is able to use scientific knowledge in problem solving; is able to connect different areas of science into one system when dealing with societal issues and discuss its with others using proper argumentation	7(16%)	*ability to use scientific knowledge when solving everyday life issues* (statement 3)*;*

Table 4 shows that for statements where the mean value was 4, 00 or higher, the most frequently mentioned level among all study groups was the third level of scientific literacy. This is the case even allowing for the fact that approximately 50% statements were determined to be at the third level (as shown in table 3). Only teacher and students studying overseas gave high mean scores to about 50% of the items indicating a high uniformity of responses to these statements. On the other hand, for statements with a mean value of 3.00 or lower, the most frequently mentioned level was the second level of scientific literacy and again this was so, allowing for the suggestion as indicated in table 3 that 36% statements were at the functional level. Only the scientist group came close to seeing about a third of the statements being of relatively low importance, this percentage dropping to as low as 5% in the case of teachers.

Table 4. The division of statements between the levels of scientific literacy among 6 study groups, given as number of statements and a percentage of the total statements at that level

	Number (% of total) statements					
	Public sector employers	Private sector employers	Scientists	Teachers	Students studying abroad	Grade 12 students
Mean value over 4,00						
Functional	2(2%)	1(6%)	2(12%)	5(30%)	8(48%)	4(24%)
Conceptual/procedural	10(50%)	6(30%)	6(36%)	16(80%)	11(55%)	5(25%)
Multidimensional	2(29%)	2(29%)	2(29%)	3(43%)	3(43%)	0
Total	14(32%)	9(20%)	10(23%)	24(55%)	22(50%)	9(20%)
Mean value under 3.00						
Functional	5(30%)	7(42%)	10(60%)	2(12%)	5(30%)	5(30%)
Conceptual/procedural	1(5%)	4(20%)	5(25%)	0	4(20%)	3(15%)
Multidimensional	1(14%)	1(14%)	1(14%)	0	2(29%)	1(14%)
Total	7(16%)	12(27%)	16(36%)	2(5%)	11(25%)	9(20%)

Further analysis of the results showed that multi-dimensional level statements, in general, were highly supported although only one statement was given a mean of 4.00 or greater by all groups (number 14, see below). In addition, 3 statements (numbers 1, 3, 22) were given a mean value of 4.00 or greater by 3 groups. It was noticeable that teachers gave all these statements a mean greater than 4.00.

Statement 14. Willingness in and interest for lifelong learning
Statement 1. Ability to judge the current situation and take actions accordingly
Statement 3. Ability to use scientific knowledge when solving everyday life issues.
Statement 22. Ability to distinguish between science and pseudoscience.

One multidimensional statement (number 17) was not given a high mean by any group and, in fact, 4 groups (public/private and both student groups) gave this statement a mean of 3.00 or lower.

Statement 17. Ability to use different strategies when solving socio-scientific problems.

The most highlighted level (the most number of statements given a high response) in all groups, i.e. the third level of scientific literacy, indicates that stakeholders are realistic about their expectations and know what they are looking for in a future employee. Nevertheless, responses towards specific statements were mixed. Of the 20 statements determined to be at level 3, all gained a mean of 4.00 or greater from at least one group, whereas half the statement were given a mean of 3.00 or less by a least one group. Only two statements (numbers 18 and 44) were give a mean of 4.00 or greater by all six groups, although statements 40 and 42 was given a high mean by all groups except scientists, and for these statements the response by scientists contrasted with the strong agreement especially by students. In fact, it is somewhat surprising that scientists should give low importance to showing initiative.

Statement 18. Ability to use creativity in professional work related activities.
Statement 44. Ability to co-operate with people with different skills and knowledge.
Statement 40. Correct language usage when compiling tests.
Statement 42. Showing initiative.

Greater diversity was shown by responses to about half the statements, deemed to be at level 3, where only a mean of 4.00 or more was given by one group, (usually teachers), typically with about 2 groups giving a mean of 3.00 or lower (often students). Statement number 9 was the least supported, with 4 groups (private, scientists and both student groups) giving a mean of 3.00 or less. A possible interpretation here is that the statement is not sufficiently meaningful to the stakeholders.

Statement 9. Ability to use scientific knowledge to predict possible changes in the environment.

As expected, fewer statements deemed to be at the functional literacy level were given high mean values - a mean value of 4.00 or higher - by any group. However, one statement (number 30) was rated highly by all groups and another (number 28) rated as quite high by all groups. These are perhaps seen as attitudinal statements rather than as a skill.

Statement 28. Ability to accept others opinions.
Statement 30. Ability to seek help when solving different problems

Contrasting this, however, only 4 functional level statements were not given a mean value of 3.00 or less by at least one group. Statement (number 19) was rated low by all groups, with statement numbers 8 and 37 by all groups except teachers (number 8) and scientists (number 37). The response by teachers is not unexpected, as formulas and laws are usual aspects in the curriculum, but it is surprising that scientists give low importance to mathematical thinking in physic and chemistry.

Statement 8. Ability to use formulas and laws taught in school.
Statement 19. Gaining Technical drawing skills.
Statement 37. Ability to solve physics and chemistry assignments using mathematical thinking.

The emphasis on the functional level, at least by teachers and students, may be caused by the overall nature of the science education system where the national examination still emphasizes factual knowledge more than both practical skills and the ability to use knowledge in problem solving. For example:

Statement 15 Ability to use modern technical equipment with manual.
Statement 16. Ability to memorize and reproduce facts and formulas taught in school.
Statement 21. Knowledge of symbolic language (writing formulas and chemical reactions).
Statement 36. Strong factual knowledge in chemistry, physics and mathematics.

Summary

From a consideration of statements attracting a mean of 4.00 or greater in table 4, all groups supported statements at level 3 (conceptual scientific literacy) as the preferred learning, with teachers and students giving more emphasis to this level. It seems there is little difference between the views of Estonian students studying abroad and grade 12 students studying in Estonia; the difference is only strongly apparent in 3 statements (numbers 3, 22 and 39).

The third level of scientific literacy is important for both employers and employees, because it enables the employees to be more independent and employers to get gain conceptually able employees, or as one participant wrote:

"…we need someone who can think with his own head and act according to the situation."

For the society it means that more people are capable of being interested in what is actually happening in their civic life and using proper argumentation and skills gained from science education to make one's life better.

The least important competencies and knowledge (lower part of table 4), in the opinion of participant, are mainly from the second level of scientific literacy. It suggests that most knowledge and skills provided in school is rather factual and not meeting employer's expectations. Students, in particular, recognized this. Nevertheless, the relatively small number of statements with a mean under 3.00 (only scientists gave over one third of statements low importance) provides positive information on stakeholders' expectations related to valuing a range of different skills and competencies. Statements at the multidimensional level rarely attracted a mean value less than 3.00 and statement 17 (with mean values less than 3.00 by 4 groups) was probably misunderstood.

When working with the Delphi method, there are some limitations (see Table 1) which this study tried to avoid. For example, when introducing the method to participants some said that they would not have enough time to participate, which reduced the number of participants because of dropping out during the study. The involvement of the experts from the science education field helped to compose the participant sample and this lessened the possibility of including stakeholders' who might drop out because they feared their expertise may not be as expected. Also seeking experts' opinion in modifying the initial question helped to minimize opportunities for misunderstanding.

Conclusion

The aim of this study was to find out whether data collected by the Delphi method can be interpreted in the light of a consideration of levels of scientific literacy. This study showed that, when precautionary steps in using the Delphi method are taken into account, learning expectations can be interpreted based on levels of scientific literacy. Although the levels were more specifically worded for the study, it was possible to organize the statements within the four levels of scientific literacy, as stated by Bybee (1997).

When comparing stakeholders' views regarding scientific literacy with those brought out in the literature (e.g. Fensham, 2007; Bybee, 1997, Holbrook and Rannikmae, 2009), it is clear that, in many cases, the stakeholders do emphasize those competencies and skills which are thought to be essential for a scientifically literate person. General, the outcomes from the small group of students studying abroad are comparable with the enlarged group of grade 12 students, thus giving confidence in accepting the Delphi study outcomes These outcomes show that knowing facts and laws still has an impact on competencies expected, especially by teachers and students. This is reflected by the emphasis on the functional level of scientific literacy by science teachers and the students.

It is important to continue the study with a greater number of stakeholders and find out which of the competencies and knowledge is essential for both future employees and citizens, if the aim of the society is a movement towards a knowledge based society (as stated in Lisbon Strategy, 2002) where scientifically literate persons are needed.

The use of the Delphi approach, paying careful attention to its disadvantages, is shown to be a good way of soliciting the views of stakeholders. It would be advantageous, using this method, to extent the range of stakeholders to include policy-makers, such as politicians and those in educational leadership.

This research is supported by ESF grant GLOLO8219 and EDUKO grant LoTeGum.

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Appendix 1. The mean values for the 44 statements with levels of scientific literacy (SL) among the 6 participating groups.

Statement	Level of SL	1st group Mean *	SD	2nd group Mean	SD	3rd group Mean	SD	4th group Mean	SD	5th group Mean	SD	6th group Mean	SD
1. Ability to judge the current situation and take actions according to it	4*	4,00	1,03	4,33	0,93	3,60	0,89	4,50	0,84	3,67	1,15	3.94	0,80
2. Ability to examine/observe processes or phenomena in the nature	3	3,13	1,38	3,50	1,36	2,80	1,1	4,33	0,82	3,33	1,15	3,00	0,84
3. Ability to use scientific knowledge when solving everyday life issues	4*	3,75	0,75	3,17	1,16	4,00	1	4,67	0,52	4,33	0,58	3,13	0,98
4. Acknowledging science as a part of society	3	4,00	0,52	3,67	0,76	2,40	1,52	3,33	0,52	4,00	1	3,41	0,95
5. Ability to speak in public about issues that demand scientific thinking	4*	4,25	0,98	3,83	0,89	3,00	1	3,83	0,75	3,00	1	3,47	0,95
6. Ability to carry a logical conversation on important topics in contemporary science	4*	3,75	0,84	3,50	0,89	3,60	0,89	3,50	0,84	4,00	1,73	3,28	1,02
7. Teamwork skills when solving problems	3	3,50	0,75	3,17	1,07	3,00	1,87	3,83	0,75	4,00	0	3,84	0,88
8. Ability to use formulas and laws taught in school	2	2,38	1,37	2,33	0,52	3,00	0,71	3,67	1,21	3,00	1,73	2,91	1,17
9. Ability to use scientific knowledge to predict possible changes in environment	3	3,25	1,26	3,00	0,89	2,60	1,14	4,33	0,82	2,67	1,15	2,88	1,04
10. Ability to find information about science and technology from foreign sources	2	3,38	1,17	2,83	1,19	1,80	0,84	3,33	0,82	4,00	1	3,50	1,02
11. Orienting in ICT equipment used in knowledge-based societies	3	3,00	1,03	2,67	0,93	3,25	0,5	4,00	1,26	2,67	0,58	3,06	1,05
12. Ability to plan and conduct a research independently	3	3,75	1,6	2,83	0,89	2,00	1,41	3,50	0,55	4,00	1	3,45	1,21
13. Ability to analyze problems with scientific content raising in society	3	4,00	1,33	2,83	0,89	3,60	0,89	3,83	0,98	3,00	1	2,88	0,98
14. Willingness and interest for lifelong learning	4*	4,00	0,75	4,17	0,52	4,60	0,55	4,83	0,41	4,67	0,58	4,26	0,89
15. Ability to use modern technical equipment with manuals	2	3,88	1,38	3,50	1,25	2,80	1,1	4,67	0,52	4,00	1	4,09	0,89
16. Ability to memorize and reproduce facts and formulas taught in school	2	2,63	0,84	2,20	1,06	3,20	0,84	3,33	1,03	3,00	1	2,72	0,77
17. Ability to use different strategies when	4*	2,63	1,05	2,50	1,19	3,20	0,45	3,50	0,55	2,67	1,15	2,72	0,85

solving socio-scientific problems													
18. Ability to use creativity in professional work related activities	3	4,25	0,82	4,33	0,89	4,60	0,55	4,33	0,52	4,67	0,58	4,00	0,88
19. Technical drawing skills	2	2,13	0,75	2,17	1,36	1,60	0,55	2,67	0,52	2,33	0,58	2,81	1,18
20. Critical evaluation of scientific texts (distinguishing reliable information)	3	3,88	0,89	4,00	1,36	3,60	0,55	4,50	0,55	4,00	1	3,34	1,10
21. Knowledge in symbolic language (writing formulas and chemical reactions)	2	2,13	0,75	1,83	1,36	2,60	1,14	3,17	0,98	3,00	1,73	3,03	1,06
22. Ability to distinguish between science and pseudoscience	4*	3,75	1,22	3,50	1,16	4,40	0,89	4,17	0,75	4,33	1,15	3,28	1,17
23. Basic knowledge in technology	2	3,38	1,37	3,67	0,92	3,20	0,45	3,83	0,98	3,00	1	3,66	1,12
24. Using correct scientific terminology when expressing ones opinion	3	3,63	0,82	3,67	1,06	3,60	0,55	4,33	0,52	3,00	0	3,06	1,13
25. Ability to find scientific information without assistance	2	4,38	0,55	3,50	0,52	3,80	0,84	4,67	0,52	4,00	1	3,72	0,89
26. Ability to make scientifically reasoned decisions when solving everyday life issues	3	2,75	1,03	3,33	1,28	3,00	0,71	4,00	0,63	3,67	0,58	3,53	0,80
27. Ability to see different knowledge gained in science classes as a whole	3	4,13	0,89	4,00	0,99	3,20	0,84	4,67	0,52	4,00	1	3,53	1,02
28. Ability to accept others opinion	2	3,63	0,75	3,83	1,19	4,40	0,55	4,33	0,82	4,67	0,58	4,37	0,76
29. Taking economic aspects into account when solving scientific problems	3	3,13	0,41	3,83	0,99	3,00	0	4,00	0,63	3,67	0,58	3,50	0,98
30. Ability to seek help when solving different problems	2	4,38	0,41	4,83	0,74	4,25	0,5	5,00	0	4,33	1,15	4,16	0,99
31. To reason one's opinion scientifically correct	3	3,63	0,75	3,83	0,92	3,50	0,58	3,83	0,41	4,00	1	4,00	0,92
32. Ability to formulate research questions	3	4,13	0,75	3,17	1,13	3,75	0,96	3,33	0,82	3,67	1,15	3,69	1,00
33. Using laws and normative when making environmental decisions	2	3,25	0,98	3,17	1,16	2,80	0,84	4,50	0,55	3,33	0,58	3,38	0,98
34. Planning and conducting research with assistance or guidance from others	2	3,75	0,82	2,67	1,04	2,60	0,89	3,83	1,17	4,00	1	3,66	1,10
35. Ability to distinguish between scientific facts and subjective opinion	3	4,13	1,03	3,33	0,83	4,00	1	4,17	0,75	4,00	1	3,69	1,06
36. Strong factual knowledge in chemistry, physics and math	2	3,38	1,21	3,67	1,19	2,80	0,89	3,50	0,55	3,33	1,53	2,78	1,21
37. Ability to solve physics and chemistry assignments using mathematical thinking	2	2,38	1,03	2,33	0,74	3,40	1,14	2,67	1,21	2,67	1,15	2,41	1,04

38. Ability to understand and explain phenomena and processes in the nature	3	4,00	0,98	3,17	1,07	4,40	0,55	4,33	0,82	3,67	0,58	3,13	0,98
39. Ability to read and understand specialized foreign texts	2	3,50	0,82	3,67	1,2	2,80	0,84	3,67	1,37	4,33	0,58	3,44	1,01
40. Correct language usage when compiling texts	3	4,38	1,17	4,17	1,06	3,60	0,55	4,33	0,52	4,33	1,15	4,00	0,92
41. Ability to recognize science content in everyday life issues	3	3,50	1,03	3,33	1,07	4,00	0,71	4,33	0,52	3,00	1	3,34	1,15
42. Initiative	3	4,13	0,52	4,67	1,36	3,80	0,84	4,17	0,41	5,00	0	4,19	0,93
43. Mathematical thinking	2	3,38	0,55	3,50	0,92	3,20	0,45	3,33	0,52	3,67	0,58	3,23	1,12
44. Ability to co-operate with people with different skills and knowledge	3	4,25	0,41	4,83	1,16	4,80	0,45	4,33	1,63	4,67	0,58	4,39	0,72

* The numbers indicate the participating groups (1-pivate sector; 2-public sector; 3-scientists; 4- teachers; 5- Estonian students studying aboard; 6- 12th grade students).