STUDENTS' AND TEACHERS' PERCEPTIONS OF SCHOOL-BASED SCIENTIFIC LITERACY PRIORITIES AND PRACTICE: A CROSS-CULTURAL COMPARISON BETWEEN CYPRUS AND GERMANY

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Abstract: Scientific literacy is an issue of paramount importance in every modern society. However, when it comes to public understanding, it seems that there is no consensus regarding what aspects should be addressed within the regular science education curriculum or how scientific literacy should be promoted. Additionally, despite the fact that teachers and students are the main stakeholders in each educational system, their voices are usually neglected. In this context, the present study employed a Delphi approach, seeking to investigate empirically the extent of any consensus between students and teachers in Germany and Cyprus, comparing their assessments regarding what science education aspects should be prioritized as well as in which extent these aspects are currently practiced. The outcome of this cross-cultural research revealed that except some minor differences, students and teachers in both countries perceive in general large discrepancies between a desired status and the status quo in science education. More specifically, science education, as currently practiced, was defined by elements from the "classic" scientific disciplines giving much emphasis on content as well as on the promotion of conceptual understanding. On the other hand, many of the greater aims of general science-related education that students and teachers gave priority to, such as the relation of science with students' interests and everyday life or the development of inquiry skills, are only rarely taken up in science classes. Following this reasoning, future educational reforms in both countries should do well to invest more efforts in order to bridge this gap between priority and praxis.

Keywords: Curricular Delphi study, scientific literacy, stakeholders, cross-cultural comparison, PROFILES

INTRODUCTION

Scientific literacy has become an issue of paramount importance in every modern society (OECD, 2007). In response to rapid scientific and technological development, several European educational systems, including those of Cyprus and Germany, have made great strides towards achieving scientific literacy for all students. At the same time, it appears that there is no definite consensus among the public regarding what aspects should be addressed within the regular science education curriculum or how scientific literacy should be promoted (Bolte, 2007, 2008). However, without a clear notion of what scientific literacy is to stakeholders, every reform effort only becomes an elusive idea (DeBoer, 2000).

PROFILES (Bolte, Holbrook, & Rauch, 2012; PROFILES, 2010), a European project that aims to promote scientific literacy in Europe and Europe-associated countries, has given much emphasis on examining the views of different stakeholders regarding aspects of science education that are considered desirable for the scientifically-literate individual of today‘s society (Schulte & Bolte, 2012). Stakeholder groups seen as relevant regarding this issue comprise students, science teachers, science education researchers and scientists. Their views were in three stages collected from the different participating countries in the PROFILES project through a Delphi methodology. The application of the Delphi methodology at a European level provides fertile ground not only for comparisons between the different stakeholders' views within each country but also for cross-cultural comparisons between the participating countries, contributing in this way to an insightful look beyond national contexts. This study compares the results between Cyprus and Germany.

THEORETICAL FRAMEWORK

According to Osborne (2003), in most societies, aspects that are both important and salient within a given domain, such as science education, are usually defined by the academic community, which inevitably suggests that the voices of educators, scientists, students or other relevant stakeholders are often suppressed. Considering the fact that teachers and students are the main and final users in each educational system, this study focuses on the presentation as well as on the comparison of students' and teachers' views regarding the promotion of scientific literacy through science education in both Germany and Cyprus. In this context, the present study seeks to investigate the following questions:

1. What similarities/differences exist between the teachers' and students' assessments regarding aspects of what should be prioritized in science education, within and between the two countries?
2. What similarities/differences exist between the teachers' and students' assessments regarding the extent in which the identified aspects are realized in science education practice, within and between the two countries?

RESEARCH METHOD AND DESIGN

A Delphi study represents a collective decision making process aiming to reach a consensus between the different stakeholders involved (Helmer, 1967; Linstone & Turoff, 1975). During the first round of the three-stage International PROFILES Delphi Study on Science Education (Figure 1), participants were asked to answer into an open-ended question regarding aspects of desirable science education. This question was specified as to situations and contexts science educational processes should be embedded, topics and fields that should be emphasized and competences and qualifications that should be enhanced regarding to promote scientific literacy. By the end of this round, all of their statements were grouped under thematic categories (Schulte & Bolte, 2012). During the second round, the stakeholders assessed on a six-tier scale the priority and the realization in practice of 88 (Germany) and 76 (Cyprus) emerged categories regarding desirable science education.

This study compares the statistical outcomes between secondary school students from Cyprus (N=48) and Germany (N=34) as well as between science teachers from Cyprus (N=18) and Germany (N=50). Mean values for each category both for students and teachers were calculated. In a second step, all of the categories were ranked according to their means. For the analysis, the ten highest and ten lowest mean values in the students' and teachers' assessments in Germany are contrasted with the ten highest and ten lowest values in the students' and teachers' assessments in Cyprus respectively, both for science education priorities and practice.

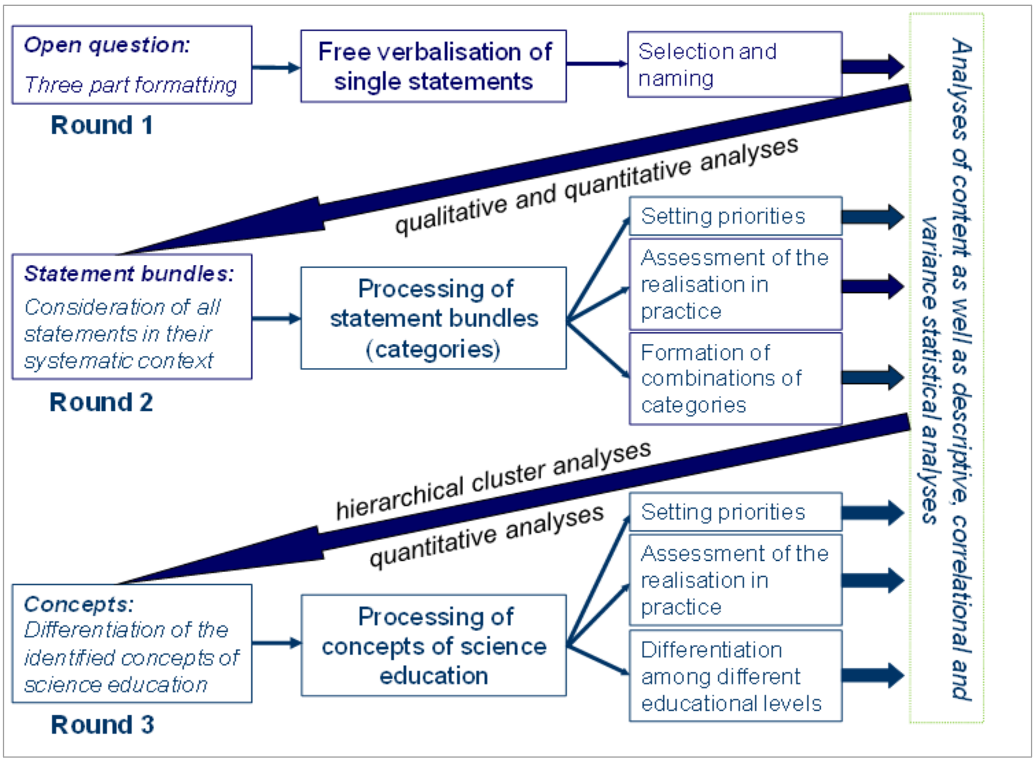

Figure 1. Method of Data Collection and Data Analysis in the PROFILES International Curricular Delphi Study on Science Education (Bolte, 2008)

RESULTS

Assessment of science education priorities

The results show that German students and teachers placed high priority on aspects that are related to the students' interests and thus motivate them. They also highly valued competences like applying knowledge, acting reflectedly and responsibly, and critical assessment as well as issues related to everyday life. Similarly, Cypriot students and teachers gave high priority to the instruction of topics that are more related to students' interests and daily lives (e.g. health/environment related issues) and prioritized contexts that can motivate students and actively involve them in the learning process. Furthermore, in addition to an emphasis on conceptual understanding, teachers attributed high priority to other types of aspects of scientific literacy relating to inquiry or basic scientific skills, while students highlighted personal competences and democratic attitudes. Students and teachers from both countries did not assign high priority on scientific sub-disciplines such as zoology, microbiology, earth science, paleontology etc. Tables 1 and 2 provide more information on the prioritization of science education aspects in each country.

Table 1

Ten Highest and Lowest Mean Values of the Priority Assessments of German and Cypriot Students

GERMANY				CYPRUS			
Category	*n*	*M*	*SD*	Category	*n*	*M*	*SD*
Comprehension / understanding	27	5,1	0,874	Equipped classrooms	48	5,4	1,005
Motivation and interest	27	5,0	1,038	Pers. competences	48	5,3	,949
Environment	29	4,9	1,012	**Health / medicine**	47	5,3	1,276
Working self-dependently / structuredly / precisely	26	4,9	0,993	Environment	48	5,3	1,062
Analysing / drawing conclusions	26	4,9	1,143	Problem-Solving	47	5,2	,770
Students' interests	33	4,9	0,857	**Comprehension / understanding**	48	5,2	1,045
Experimenting	26	4,8	1,120	Democratic attitudes	48	5,2	1,299
Critical assessment	26	4,8	0,732	**Students' interests**	48	5,2	1,078
Health / medicine	29	4,8	1,071	**Experimenting**	48	5,2	,975
Judgement / opinion-forming / reflection	27	4,8	1,001	Use of audiovisual material	48	5,2	1,255
…	…	…	…	…	…	…	…
Thermodynamics	28	3,8	0,967	Integration of assessment practices	47	4,3	1,293
Earth sciences	29	3,7	1,192	Scientific literacy	48	4,3	1,391
Empathy / sensibility	25	3,6	1,075	Socio-scientific issues	47	4,2	1,313
Out-of-school learning	33	3,6	1,342	Use of sc. terminology	47	4,2	1,388
Industrial processes	30	3,6	1,098	**Earth sciences**	47	4,2	1,469
History of the sciences	28	3,5	1,232	Economics	48	4,2	1,468
Botany	30	3,4	1,406	**History of the sc.**	47	4,0	1,489
Zoology	30	3,3	1,241	Demographics	48	3,9	1,574
Emotional pers. development	31	3,3	1,243	Palaentology	48	3,9	1,403
Astronomy / space system	29	3,1	1,423	Architecture	48	3,9	1,557

Note. *n* = Number of Participants, *M* = Mean Value, *SD* = Standard Deviation

Table 2

Ten Highest and Lowest Mean Values of the Priority Assessments of German and Cypriot Teachers

GERMANY				CYPRUS			
Category	*n*	*M*	*SD*	Category	*n*	*M*	*SD*
Applying knowledge / creative and abstract thinking	44	5,4	0,838	Health problems	18	5,9	,236
Acting reflectedly and responsibly	44	5,3	0,668	**Comprehension / understanding**	18	5,9	,323
Nature / natural phenomena	47	5,3	0,877	Basic scientific skills	18	5,8	,383
Comprehension / understanding	44	5,3	0,624	Inquiry Skills	18	5,8	,428
Critical assessment	44	5,3	0,781	**Experimenting**	18	5,7	,461
Everyday life	47	5,2	0,666	Social skills	18	5,7	,461
Judgement / opinion-forming / reflection	44	5,2	0,774	Positive attitudes towards Science	18	5,7	,461
Rational thinking / analysing / drawing conclusions	44	5,2	0,774	Environmental Actions	18	5,7	,485
Perception / awareness / observation	44	5,2	0,823	Mathematics	18	5,7	,767
Experimenting	44	5,1	0,784	Human physiology	18	5,6	,608
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Zoology	43	3,9	1,005	Meteorology	18	4,2	,878
Microbiology	42	3,9	1,299	**History of the sciences**	18	4,2	,985
Technical devices	45	3,8	1,043	**Astronomy / space system**	18	4,1	,583
Botany	43	3,8	0,965	Integration of assessment practices	18	4,0	1,085
Emotional pers. development	50	3,8	1,222	Non PC games	18	3,9	1,305
Earth sciences	42	3,7	0,939	Architecture	18	3,8	1,215
Analytical Chemistry	45	3,6	0,806	Lectures	18	3,7	1,320
Industrial processes	45	3,5	1,121	**Earth sciences**	18	3,7	,840
History of the sciences	44	3,5	1,110	Palaentology	18	3,4	1,243
Astronomy / space system	41	3,1	1,352	Digital games	18	3,4	1,335

Note. *n* = Number of Participants, *M* = Mean Value, *SD* = Standard Deviation

Table 3

Ten Highest and Lowest Mean Values of the Practice Assessments of German and Cypriot Students

GERMANY				CYPRUS			
Category	*n*	*M*	*SD*	Category	*n*	*M*	*SD*
Terminology	28	4,8	0,917	Mathematics	48	4,2	1,779
Curriculum framework	31	4,7	0,815	Physics	48	4,0	1,762
Science – chemistry	31	4,5	0,850	Environmental Actions	48	4,0	1,368
Genetics / molecular biology	28	4,4	0,959	Physics modules	48	3,8	1,389
Chemical reactions	30	4,4	0,968	Use of textbooks	47	3,8	1,537
Models	28	4,4	1,311	**Ch. reactions**	48	3,8	1,633
Structure / function / properties	30	4,3	0,952	Human physiology	48	3,8	1,468
Content knowledge	26	4,2	0,951	Health problems	47	3,8	1,614
Matter / particle concept	29	4,2	1,114	**Science – biol.**	48	3,8	1,477
Science – biology	31	4,2	0,980	Environmental Phenomena	47	3,7	1,390
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
History of the sciences	27	2,9	1,207	Current Issues	48	2,5	1,571
Empathy / sensibility	25	2,9	1,236	Earth sciences	47	2,5	1,472
Consequences of technol. Developments	27	2,9	1,199	Palaentology	48	2,4	1,569
Neurobiology	28	2,8	1,156	Interaction with experts	48	2,4	1,485
Knowledge about science-related occupations	25	2,7	1,308	**Out-of-school learning**	48	2,4	1,300
Ethics / values	26	2,6	1,169	Nuclear Physics	47	2,4	1,512
Current scientific research	26	2,6	1,137	Non PC games	48	2,4	1,424
Out-of-school learning	32	2,5	1,107	Digital games	48	2,3	1,277
Emotional pers. development	32	2,4	1,014	Meteorology	47	2,2	1,366
Astronomy / space system	27	2,2	1,178	**Astr. / space**	47	2,2	1,414

Note. *n* = Number of Participants, *M* = Mean Value, *SD* = Standard Deviation

Table 4

Ten Highest and Lowest Mean Values of the Practice Assessments of German and Cypriot Teachers

GERMANY				CYPRUS			
Category	*n*	*M*	*SD*	Category	*n*	*M*	*SD*
Curriculum framework	48	4,8	1,225	Physics modules	18	4,6	1,037
Content knowledge	43	4,5	1,241	Mathematics	18	4,6	1,037
Chemical reactions	46	4,4	1,236	Physics	18	4,6	,984
Structure / function / properties	46	4,4	1,181	Human physiology	18	4,5	,857
General and inorganic chemistry	45	4,3	1,148	Natural phenomena	18	4,3	1,179
Organic chemistry	43	4,3	1,049	**Matter / particle concept**	18	4,2	,808
Ecology	43	4,2	1,067	Chemical phenomena	18	4,2	,943
Matter / particle concept	46	4,1	1,272	Study of the cell	18	4,2	,857
Science – biology	46	4,1	1,272	Terminology	18	4,1	1,183
Nature / natural phenomena	47	4,0	1,043	Physics theories	18	4,1	1,183
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Limits of scientific knowledge	45	2,6	0,883	History of sc. theories	18	1,9	1,056
Occupation / career	47	2,6	1,074	Architecture	18	1,9	,938
Consequences of technol. Developments	44	2,6	1,061	Interaction with experts	18	1,9	,900
Ethics / values	44	2,4	1,108	Nuclear Physics	18	1,8	,786
Out-of-school learning	49	2,4	0,913	Geology	18	1,7	,895
Current scientific research	44	2,4	1,064	**Out-of-school learning**	18	1,7	,907
Occupations	45	2,4	0,963	Digital games	18	1,6	,984
Astronomy / space system	41	2,3	1,078	Non-pc games	18	1,5	,707
Knowledge about science-related occupations	44	2,3	0,943	Meteorology	18	1,4	,608
Emotional pers. development	49	2,2	0,808	Palaentology	18	1,3	,461

Note. *n* = Number of Participants, *M* = Mean Value, *SD* = Standard Deviation

Assessment of science education practices

In both countries, the highest mean values in the students' and teachers' assessments were assigned to scientific disciplines such as biology, physics or mathematics and to the teaching of traditional topics (e.g. chemical reactions, matter/particles concepts). Furthermore, the assessments from both countries place emphasis on the traditional teaching practices currently employed. For instance, teachers and students in Germany highlighted that there is great focus on the promotion of content knowledge while students in Cyprus gave emphasis on the employment of traditional approaches such as using textbooks or terminology. The results also indicated that aspects rated as important in the science education priority assessments were perceived as less present in science education practices in both countries. Tables 3 and 4 provide more information on these results.

DISCUSSION

Our cross-cultural comparison rendered a significant contribution to clarifying the socially desirable goals of science education for the promotion of scientific literacy in Cyprus and Germany, setting up the base for a successful curriculum reform. Despite some minor differences that might have mainly resulted from the cultural differences, both students and teachers in Cyprus and Germany considered the same, overall, categories as especially important or practiced. More specifically, students and teachers in both countries gave high priority to:

(a) the instruction of scientific issues related to students' interests and lives,

(b) the employment of scientific inquiry and

(c) the development of scientific skills and attitudes.

On the other hand, the comparison of the science education practice assessments indicated that in both countries, aspects relating to

a) traditional scientific disciplines,

b) content knowledge and

c) traditional teaching approaches

were considered as prevailing in local science educational practices. It can be concluded from these considerations that students and teachers, in both countries, perceive large discrepancies between an ideal state and the current status quo in science education. Future educational reforms in both countries should do well to invest more efforts in order to bridge this gap between priority and praxis.

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