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Primary and Secondary School Differences in Thinking about Learning Science

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Abstract: Samples of teachers and pupils (primary & secondary) in five countries (Czech Republic, Cyprus, France, Ireland, & Slovenia) completed questionnaires concerning dimensions of their thinking about learning science that reflect aspects of the constructivist approach. The dimensions concerned the actual experience of (1) teachers' and (2) pupils' and (3) teachers' desired experience in relation to (1) personal relevance/ learning about the world; (2) uncertainty/ learning about science; (3) critical voice/ learning to speak out; (4) shared control/ learning to learn; and (5) student negotiation/ learning to communicate. There were significant differences between countries in each of these three data sets. Results are discussed in terms of the convergences and divergences between primary and secondary data in each country in each of these three domains for the five variables. The issue is whether science teaching is represented as about memorising or about investigating.

Keywords: Constructivist teaching, teachers' perceptions, pupils' perceptions, National differences

Introduction

There have been a series of high level policy statements in Europe about the need for education. The Lisbon EU Summit of March 2000 declared: "*Europe should be the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion"* (European Commission, 2005). This sentiment was reiterated by Marianne Thyssen (2008), EPP-ED Coordinator for the Lisbon Strategy, in addressing the Spring Council of the European Parliament in March 2007; *"We owe it to the next generation to respond to the challenge of today - the challenge of globalisation. To be able to face global competition with an ageing population and a changing climate, we need to make sure Europe remains competitive"*. Supporting science and engineering is the only way Europe and her individual countries can compete in terms of attracting the skilled individual companies need for high-tech innovation essential for sustaining the economy through the challenges of the twenty first century. In spite of these assertions, and at a time when scientific advances are affecting society profoundly and when societies need to understand and use science in everyday life, insufficient numbers of students choose scientific careers (OECD, 2006). For example, in Ireland concern has been expressed at the low numbers of students choosing science in universities (O'Hare, 2002), an issue in subsequent years through media reports, and at the declining quality of students' qualifications graduating with science degrees (Royal Irish Academy, 2009). Similar disaffection with science has been documented in other countries and has led to discussion about how best to approach science education in primary and secondary schools (Group interuniversitaire projet Sophia, 2009; Rocard, 2007, p. 8 citing the Directorate-General for Research, 2005; & OECD, 2006). In many countries around the world science curricula are changing and similar concerns have been expressed about the vitality of science teaching prior to university entrance. However, there seem to be signs of a slowly emerging consensus regarding the direction to move pedagogically: that is, towards constructivist instruction (Tobias & Duffy, 2009) and in the European Union towards an 'inquiry-based learning' (IBL) approach (Rocard, 2007; Linn *et al.*, 2004a, 2004b, 2006).

Constructivism has been seen as a desirable background to learning environments in science; so much so that it has been written into some National curricula, see for example, Ireland (NCCA, web reference) However, traditionally, schools have offered science in the "transmission of knowledge" paradigm and one question that arises is whether in the classroom or laboratory one finds a constructivist learning environment unfolding. Constructivism raises questions about how teachers can engage students in something other than memorization or recall of facts. Taylor *et al*. (1996) suggest that teachers must adopt an educational interest in their students as learners; and importantly, such an interest must transcend their own fascination with science and concerns surrounding the delivery of course content (Taylor *et al*., 1996). Therefore, the interpersonal relationships between

teachers and students are paramount. Bauersfeld (1988) and Tobin (1990) described how the quality of both classroom discourse and interpersonal relationships amongst teachers and students has a direct impact on the quality of the knowledge constructed. In order to assess the quality of teacher - student interpersonal relationships, and the teacher's reflection of the same, Peter Taylor and Barry Fraser developed the Constructivist Learning Environment Survey (CLES); see for example, Taylor & Fraser (1991) and Taylor *et al*., (1994, 1995). In a currently active Comenius project, *SOPHIA*, we aim to design in collaboration with serving teachers, constructivist learning environments. However, it is not known firstly to what extent such environments exist. Anecdotally, two pictures emerge: (i) teachers may think they are teaching constructivistically but there is no evidence of constructivism; or (ii) teachers do not believe that the behaviours and approach of constructivism has anything to offer teaching and learning in science. In both cases, teachers' beliefs are important for constructivism to thrive, however, knowledge of teacher's beliefs remains anecdotal, and thus data is needed.

Method

The data reported at this conference come from a Comenius project that included five countries (France, Cyprus, Czech Republic, Ireland and Slovenia) and was designed to provide ways to facilitate constructivist teaching at upper primary and lower secondary schools (Valanides, 2009). The aim of the present study is to examine whether there are differences in teacher and pupil perceptions of science classrooms between upper primary and lower secondary samples in each participating country. To understand the context of the educational practices in each participating country in our Comenius project, we collected data from teachers and from pupils in each of the participating countries concerning ways they thought about teaching-learning using the CLES questionnaires (see Appendix) which contain questions that allow insight into the extent that classroom practices might be considered constructivist.

Results

Data on pupils in primary and secondary schools

Country by school level: numbers at primary & secondary level

Count

		primary secondary		
		Primary	secondary	Total
country	Ireland	86	81	167
	France	68	50	118
	Slovenia	67	55	122
	Czech	67	133	200
	Cyprus	77	48	125
Total		365	367	732

We anticipated that there would be differences between primary and secondary pupils in terms of the ways they thought about learning. The dimensions were; personal relevance (learning about the world; 1-6), uncertainty (learning about science; 7-12), critical voice (learning to speak out; 13-18), shared control (learning to learn; 19-24) and student negotiation (learning to communicate; 25-30).

To compare ways pupils answered these dimensions on the questionnaire, independent sample t-tests were prepared contrasting the mean scores of pupils sampled in primary with pupils sampled in secondary classes in each country separately. For Ireland the data were as follows for the five variables: These differences were all significant.

Significant mean pupil differences on CLES variables - Ireland

Quest.	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
1-6	primary	85	20.79	4.78	.52
	secondary	81	17.42	6.04	.67
7-12	primary	85	19.80	4.19	.45
	secondary	81	16.91	4.35	.48
13-18	primary	86	19.02	5.94	.64
	secondary	81	15.24	7.05	.78
19-24	primary	86	12.72	5.32	.57
	secondary	81	10.41	4.91	.55
25-30	primary	86	22.22	5.47	.59
	secondary	81	13.36	6.16	.68

For the French sample the differences were not all significant, so indicating that there is more harmony in the pupils' understanding of teaching-learning in primary and secondary schools in France than there was in the Irish sample.

Significant mean pupil differences on CLES variables - France

Quest.	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
7-12	primary	68	15.97	4.55	.55
	secondary	50	19.14	6.03	.85
25-30	primary	68	19.07	4.88	.59
	secondary	50	16.66	6.81	.96

The significant differences were for the variables uncertainty ($p<0.001$) (7-12) and student negotiation ($p<0.05$) (25-30) and imply that learning about science is much more developed in secondary schools than in primary schools in France and also that student negotiation about science in class by interacting with pupils in France is much more part of what happens in primary schools than in secondary schools.

In the Slovene sample there were significant differences (in each case $p<0.005$) between the primary and secondary school samples on the first two variables personal relevance (1-6) and learning about science (7-12). In each case the pupils sampled in primary schools achieved higher scores than the secondary school pupils.

Significant mean pupil differences on CLES variables - Slovenia

Quest.	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
1-6	Primary	67	22.94	3.93	.48
	secondary	55	20.78	3.41	.46
7-12	Primary	67	22.97	4.37	.53
	secondary	55	20.84	3.49	.47

In the samples tested in the Czech Republic there were differences in each variable except shared control (19-24). The primary school children samples had significantly higher scores ($p<0.001$) than secondary school pupils on the variables personal relevance (1-6), and ($p<0.005$) uncertainty (7-12). The Czech pupils in secondary schools sample in turn scored significantly higher ($p<0.05$) in terms of critical voice (13-18), and ($p<0.001$) student negotiation (25-30).

Significant mean pupil differences on CLES variables – Czech Republic

Quest.	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
1-6	Primary	67	23.13	3.47	.42
	Secondary	133	20.64	3.37	.29
7-12	Primary	67	20.12	3.96	.48
	Secondary	133	18.44	3.52	.31
13-18	Primary	67	19.28	5.22	.64
	Secondary	133	20.92	5.60	.49
19-24	Primary	67	11.10	4.80	.59
	Secondary	133	12.29	5.02	.43
25-30	Primary	67	15.75	5.68	.69

Secondary	133	19.53	5.59	.48

Interestingly, the data from the primary and secondary schools in Cyprus did not differ on any of the variables.

Data from the teachers' questionnaires

In the Irish sample there were only two differences in the ten analyses that were significantly different (personal relevance and student negotiation). In each case ($p<0.001$) primary teachers scored higher than secondary teachers.

Significant mean teacher differences on CLES variables - Ireland

	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
Q 1-5 perceived	primary	46	20.48	2.57	.38
	secondary	23	18.04	3.40	.71
Q 21-25 perceived	primary	46	20.76	3.17	.47
	secondary	23	17.04	4.04	.84

In the French ($p<0.05$) and Slovenian ($p <0.001$) samples there was only one variable on which primary and secondary teachers were significantly different, this was the variable student negotiation. In each case this aspect of science teaching was more prominent for primary than secondary teachers.

Significant mean teacher differences on CLES variables – France

	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
Q 21-25 perceived	Primary	17	21.94	2.97	.72
	Secondary	43	19.21	3.94	.60

Significant mean teacher differences on CLES variables – Slovenia

	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
Q 21-25 perceived	Primary	29	21.69	2.07	.38
	Secondary	50	19.62	2.70	.38

In the Cypriot sample there were differences between primary teachers and secondary teacher's responses on two parallel sets of variables that are in the case of both experienced and desired classroom dimensions for personal relevance (1-5), shared control (16-20) and student negotiation (21-25). In each case the primary teachers (higher scores) were more open to constructivist approaches than the second level teachers who leaned towards instructional approaches (lower scores).

Significant mean teacher differences on CLES variables – Cyprus

	primary secondary	N	Mean	Std. Deviation	Std. Error Mean
Q 1-5 perceived	primary	39	20.13	2.45	.39
	secondary	31	17.42	3.25	.58
Q 16-20 perceived	primary	39	17.54	4.20	.67
	secondary	31	14.42	4.56	.82
Q 21-25 perceived	primary	39	19.77	2.37	.38
	secondary	31	16.65	3.76	.68
Q 1-5 wished	primary	39	23.52	1.92	.31
	secondary	31	21.55	3.34	.60
Q 16-20 wished	primary	39	21.10	3.59	.58
	secondary	31	17.87	4.91	.88
Q 21-25 wished	primary	39	23.74	1.89	.30
	secondary	31	21.16	2.87	.52

Discussion and Summary

The debate around the importance of pedagogical methods focuses on the desire to facilitate pupil interest in science and the desire to facilitate good exam results. The former desire is at the heart of constructivist instructional approaches, and the latter reflects a more traditional view of education where memory is most important. A few years ago a debate was held at the AERA 2007 conference following a polemical article by Kirschner, Sweller and Clarke (2006) with the title "Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching". This debate led to a book edited by Tobias and Duffy (2009) where the issues were considered I believe some rapprochement was achieved. In terms of science education one of the issues was that the traditionalist view of education where memory is prioritised considered that educational methods based on the epistemology of science were misplaced. Duschl and Golan Duncan (2009) take the constructivist view that teaching science is centrally about theory building and learners also need to be able to engage in activities such as

modelling, arguing and evaluating in order to assess knowledge claims and restructure knowledge via conceptual change.

In what follows, aspects of the CLES questionnaires illustrate the comparative preference of the primary (in contrast to secondary) school pupils and teachers for pedagogical approaches facilitating constructivist instruction. One of the ways constructivist approaches seek to involve pupils' interests is by making the curriculum relevant to the pupil. On this variable there were more differences favouring primary participants than on the other variables: Czech, Irish and Slovene pupils and Cypriot and Irish teachers were more positive about relevance at primary than secondary level, and in addition Cypriot primary teachers wished for more relevance. It may be that this is the easiest aspect of constructivist instruction to implement. An associated feature clearly important for mutually respectful dialogue in class assessing knowledge claims is "critical voice". This variable reflects the extent that pupils may voice their feelings about the teaching in a lesson. In our discussions there were clearly significant national differences reflecting values about respect for adults! Here, however, we are concerned with pupils sense of being equal partners in the teaching/learning process and of course with differences between primary and secondary participants. It is the Irish primary pupils, and Cypriot primary teachers (both perceptions and wishes) who are more accepting of pupils' critical voices in contrast to their secondary peers and colleagues. Similarly, shared control is about pupils being free to participate in lesson planning, also entailing a different balance in the teacher pupil relation. Again Irish primary pupils saw this as more relevant to their experience than Irish secondary pupils.

The uncertainty variable appears to be more about the philosophy of science, though these questions clearly also reflect a tolerance of uncertainty concerning topics of science lessons. Only with the pupil data were there differences between primary and secondary participants: the primary Czech, Irish and Slovene pupils favoured this variable and so did the secondary French pupils. This might be fruitful to follow up with qualitative data because it may be, for example, that the French desire to criticise and evaluate led to these French secondary pupils "outperforming" their primary peers. In France, for example, my impression was that there were many News Bulletins citing the reluctance of young French adults to reject the H1N1 vaccine on the grounds that it had not been proven "safe". Such discussions were comparatively low profile in our experience in Ireland.

Finally, in four countries teachers at primary level prioritised student negotiation and communication more than at secondary level. These were the Irish French Cypriot and Slovene teachers. The Cypriot teachers also wished for this more at primary level than secondary level. The Irish primary pupils and interestingly, the French secondary pupils also favoured more student negotiation. The high numbers of significant differences here point to the ease of implementation of

this feature of the constructivist approach in the primary sector, with the French secondary pupils providing an interesting counter-example.

We do not wish to make strong statements about how these data generalise to varieties of different types of schools in the respective countries. We recognise that our samples were relatively small. However, we did find that the participating teachers were interested in the results – often confirming their views on the importance of their own ways of teaching. An important part of future in-service work with science teachers, therefore, may be to use questionnaires like these to establish self portraits of teachers' implicit epistemologies. This work could be followed by working with teachers and pupils about ways guided approaches can be used to facilitate constructivist instruction to facilitate both student and teacher engagement in genuine cognitive and personal development in schools.

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