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‘Transformation’ of the intended science curriculum

A tension between instrumental and liberal purposes

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HÁSKÓLI ÍSLANDS

‘Transformation’ of the intended science curriculum[1]

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Reaching a consensus on the contents and purposes of the official school curriculum is not an easy task. There will always be disagreements over what knowledge is of most worth and to what extent education should promote students’ capacity to critically address societal issues. This tension has appeared to a distinct degree in science education through a competition between instrumental and liberal purposes. This paper presents results from analyzing the intended science curriculum for Icelandic compulsory schools in that respect. Sources of data are the official curriculum guides for compulsory education in effect for the last four decades of the twentieth century, issued in 1960, 1976 and 1989 and some related documents. A classification of curriculum ideologies was used as model for analyzing the data. The results indicate a constant tension between instrumental and liberal purposes of science learning. The three official curriculum guides examined in this study differ markedly with respect to ideologies that have shaped their contents.

Science as a curricular field in compulsory education

The term ‘science’ is usually not used in Icelandic, and ‘natural science’ is seldom used. In official curriculum guides and reports the term ‘nature study’ (*náttúrufræði*) is normally applied when referring to the field or subject that covers the study of living and dead natural phenomena, typically under the rubrics of biology, physics, chemistry and earth sciene. This has turned out to be problematic because traditionally ‘náttúrufræði’ has by many scholars and layman been conceived as the study of life and living things exclusively. Studying the part of nature that is insentient on the other hand has frequently been conceived as unconnected to life science, and called real subjects (*raungreinar*), real science (*raunvísindi*) or simply physics and chemistry. Natural science is an ever expanding and multiplex field with various perspectives and emphases, a mixture of different kinds of visions and educational aims, rather than a rigidly defined school subject (Donnelly, 2006).

‘Transformation’

The term ‘transformation’ is placed within quotation marks to indicate its conditional meaning. Other terms frequently used in the literature in this respect are ‘educational reform’, ‘educational change’, and ‘educational progress’. They are often used

[1] The paper is a continuation of a paper presented at the annual Icelandic Social Science Conference, *Þjóðarspegill,* in October 2009. The first paper described the theoretical framework and rationale that underlie a study on the ‘transformation’ of the science curriculum.

interchangeably (Horn, 2002), but 'reform' usually denotes that a system supposedly needs improvement and new solutions are offered, while 'change' implies that it will be altered. Assuming that the term 'progress' means perennial growth and improvement it is important to emphasize that neither educational reform nor educational change guarantee progress of that kind.

As affirmed by Black & Atkin (1996) in their monograph about case-studies in science, mathematics and technology education for OECD, a myriad of national reports, papers and books proposing educational change in science alone have been issued in developed countries in recent decades, implying that science is indeed one of 'the most revised of established curricular areas, at least in respect of proposals for reform' as Donnelly argued (2006, p. 623).

Instrumental and liberal purposes

James Donnelly (2006) described transformation of the science curriculum as involving tensions between the 'instrumental' purpose and the 'liberal' purpose. The distinction between instrumental and liberal purposes draws on Plato's ideas of education, who argued that the difference lay in our conceptions of knowledge. According to Plato acquisition of knowledge from the liberal perspective aimed at promoting personal learning and growth, supporting each individual´s unique potential, while the acquisition of instrumental knowledge aimed at enhancing the ability to function in society, acquiring knowledge and skills as power in a societal context.

Donnelly and Jenkins (2001) portrayed the perpetual impulses for curricular changes in science education as a sort of religious correctness: 'The view that the science curriculum must change has become so common as to be an orthodoxy' (p. 2), where the above delineated tension played a central role. For the past decades the national curriculum in Iceland seems to have undergone similar changes or transformations as other Western school curricula (Allyson Macdonald, 1993, 2000) affected by similar philosophical and socio-cultural ideologies. But the waves of change usually reached the shores of Iceland some years later than in other countries. As an example, the major wave of curricular reform in science education starting in the mid-1950s and lasting until the end of the 1970s reached Iceland in the late 1960s and the next wave starting some 40 years ago, characterized by the need for an enlightened citizenry under the rubrics of scientific literacy and STS (science, technology and society), reached the shores of Iceland about 20 years later (Allyson Macdonald, 1993).

Exploring the intended curriculum

The intended curriculum is usually conceived as the official, written curriculum, issued by the authorities that shape the educational policy. Its rationale 'serves as major orientation point' (van den Akker, 2003) for other important components of the curriculum in its broadest sense, such as aims, content, learning contexts, teacher roles, learner roles and assessment. As many curriculum theorists have argued (Ellis, 2004; Kliebard, 1996; Ornstein & Behar-Horenstein 1999; Schiro, 2008; Walker & Soltis, 1997) there are various approaches to curriculum development and ways of exploring it. Herbert Kliebard (1996) and Michael S. Schiro (2008) identified four ideologies that have shaped the transformation of the school curriculum for the past century or so. Kliebard described them as humanist (or mental disciplinarian), social efficiency, developmentalist (or child study), and social meliorists. Schiro labelled

them scholar academic ideology, social efficiency ideology, learner-centered ideology, and social reconstruction ideology. When exploring the intended curriculum these can be identified as follows (Table 1) according to perspectives towards knowledge, teaching, learning and assessment of learning:

Table 1. Curriculum ideologies (Donnelly, 2006; Kliebard, 1996; Schiro, 2008)

INSTRU-MENTAL **SUBJECT-TEACHER CENTERED**	**Scholar academic, Mental disciplinarian**	Knowledge as didactic statements to be transmitted. Learners seen as neophytes in a hierarchical community of the academic disciplines. Assessment as gathering objective data on student learning achievement.
	Social efficiency	Knowledge gives learners the ability to function in society, teaching involves shaping behaviour, learners are the raw material to be shaped. Assessment as means to determine acceptance or rejection (pass or fail).
LIBERAL **STUDENT CENTERED**	**Learner-centered Developmentalist**	Knowledge is personal, based on prior conditions, a derivative of each individual's learning and growth, teaching and learning as interactive exercieses, learners are self-activated makers of meaning. Assessment as means to promote learning and teaching.
	Social reconstructionist Social meliorist	Knowledge gives individuals the ability to interpret and reconstruct their society, teaching and learning seen as acculturation into an alleged good society. Learners are intelligent, social beings who´s critical thinking should be promoted. Assessment subjective, holistic.

When analyzing the science curriculum according to this classification it turns out that the scholar academic and social efficiency ideologies are strongly characterized by the 'instrumental purpose' as described above (Donnelly, 2006), i.e. generating scientifically-educated citizens by transmitting objective content that learners need to pick up and be able to recite. The learner centered and social reconstructionist ideologies on the other hand are characterized by the 'liberal purpose', focusing on students as critical human beings and enhancing their informed autonomy.

But it should be noted that such classification of curriculum ideologies represents ideals 'abstracted from reality, and not reality itself' (Schiro, 2008) implying that real rhetoric, both written and oral discourse is floating somewhere in between these extreme ideals of dynamic curricula. Meanings of concepts are also contextual. As an example, some people might assume that the scholar academic ideology conforms with the the liberal purpose of education, since it empowers studens with knowledge and skills for promoting personal growth. But according to current views on education, the scholar academic ideology is envisioned as learning and teaching the academic disciplines as prescribed by the educational authorities, which does not fit well with liberal purposes.

Method

The curriculum guides for compulsory education in Iceland, issued in 1960, 1976 and 1989 were analyzed and compared with respect to the above classification of curriculum ideologies, focusing on the field called *nature studies* (*náttúrufræði*) or *natural science* as it transformed through the last decades of the twentieth century. It is a typical text analysis where the purpose is to identify specified characteristics of the content of the official curriculum guides (Ary, Jacobs, Razavieh, & Sorensen, 2006). The phenomena being investigated are the ideologies found as bases or rationale for science learning in the Icelandic compulsory curriculum 1960–2000. The media observed are the three official curriculum guides in effect during the last four decades of the last century. Coding and analysis of data is built on the classification as described above (Table 1), i.e. what ideas emerge from each curriculum guide about *knowledge*, *learning and teaching*, *the learner* and *assessment* with respect to the ideals discussed by curriculum theorists. The texts of the curriculum guides were studied as to analyze the relationship between words and their meaning. So discourse analysis is applied in the sense that the system of relations between words and their meanings, i.e. the languge used is viewed as a social contruct.

Results

Sources of data in this part of the study are the official curriculum guides in effect from 1960 to 1999. Science covered only about 3–7 % of the whole compulsory curriculum during this period measured in pages. Broad aims on the one hand and specifically stated objectives on the other have appeared as recurring cycles which applies also to central testing. Pedagogical views, i.e. placing emphasis on learning experiences with respect to theories on learning and teaching, have also been up and down.

Tension

All the curriculum guides have had their preludes, i.e. periods of discussion about political, cultural and pedagogical emphases. Committe reports, recommendations and policy papers are usually issued in connection with the curriculum publications, shedding light on the political context of the official curriculum development. Additionally there are other sorts of data that confirm the constant tension between instrumental and liberal purposes. Among files that are being analyzed in this study are proceedings and memos about curriculum work reserved in the Ministry of Education archives.

Many such files indicate a clear tension between professional scholars in the field of science education working for the ministry and representatives of the bureaucratic authority in the ministry or even higher politically elected authority. An interesting example is a debate about the concept of 'knowledge' in a draft of the 1989 curriculum (Menntamálaráðuneytið, skjalasafn, n.d.). The bureaucrat was worried that the text was not conclusive enough about the requisition that students should acquire scientific knowledge per se in compulsory schools: 'The compulsory school (*grunnskólinn*) is certainly not only a preparation for the secondary school ... It has its independent goals, among other things regarding students knowledge'. The scholar maintained on the other hand that the compulsory school should emphasise enquiry learning, where the students ought to encounter natural phenomena, and discover their nature: 'It fascinates many students more to acquire knowledge through

challenging means from original sources, and by observing and experimenting rather than assimilating solely what others have acquired and put into books'.

1960

The 1960 curriculum, labelled *Námskrá fyrir nemendur á fræðsluskyldualdri* (*A curriculum for students on the age of compulsory schooling*), was in effect for 16 years from 1960 to 1976. It was built on the Educational Act from 1946, having been written as draft in 1948, but not finally published until 12 years later. According to the introductory chapter the prescribed curriculum has an exemplary or voluntary status, 'its role is first and foremost to guide teachers and administrators about organization and selecting learning contents' where teachers and adminstrators 'make sure that each student gets proper assignments according to his or her capability' (Menntamálaráðuneytið, 1960, p. 5). The curriculum was published in one book divided into chapters according to the names of the school subjects to be taught. Each subject chapter was then divided according to the age of students from 7 to 15 and what was to be taught and learnt in each grade.

The chapter on nature study covered pages 41–46 starting with a few lines about general aims concerning 'nature study instruction' which 'is supposed to help students acquire knowledge about the predominant phenomena of nature, focusing on what they need to know about with respect to daily life' (p. 41). Then there are subchapters that resemble a sort of catalogue about what should be taught and learnt:

> Example 1:
> Icelandic mammals and birds: Instruction should focus on body characteristics, body structures, offspring ... Learning should focus on knowing the main characteristics of mammals and birds (p. 41).

> Example 2:
> Chemistry: Chemicals, compounds, elements, molecules and atoms. Elements of the atmosphere. Combustion, corrosion, water. Distillation. Elements of water. Alkali, acid and acetates (p. 44).

At the end of each subject chapter in the curriculum there was a subchapter called 'For further reviewing' (*Til athugunar*), with some interesting recommendations about the process of learning and teaching. In the subject chapter about natural science the curriculum authors argue about the importance of relating new knowledge to prior learning, using the natural environment of the school as subject matter, appreciation of nature and wildlife conservation. And finally there are suggestions about hands-on learning, that students discuss and present their work orally and in writing. Making workbooks in natural science is considered important.

According to the above analysis, the 1960 curriculum is primarily characterized by the instrumental purpose, it is subject–teacher centered. Knowledge is to be transmitted, providing learners with the ability to function in society. Teaching involves shaping behaviour, where learners are the raw material to be shaped. Although there are no clauses about assessment specifically, the structure of the curriculum is in favour of the view that assessment involves gathering objective data about the achievement of learning.

But the 1960 curriculum is not solely under the influence of mental disciplinarian and social efficiency ideologies. As the subchapter 'For further reviewing' indicates, pedagogic theories of child development and consequently the liberal purpose of education is certainly taken into consideration. There are even signs of social constructivist methods of learning.

1976

The 1976 curriculum (Menntamálaráðuneytið, skólarannsóknadeild, 1976) was issued in 10 booklets under the rubric of *Aðalnámskrá grunnskóla* (*The national curriculum for compulsory schools*). It was in effect for 13 years from 1976 to 1989, built on the Educational Act from 1974. Natural science was divided into physics including chemistry and biology. Learning materials and all discourse about science aimed at dissociating these two facets of natural science, physics-chemistry on the one hand and biology on the other hand. The physics-chemistry curriculum was issued in September 1976, but the biology part was never completed. Two officially appointed committees on science education, one on physics-chemistry, the other on biology, published reports with recommendations about the reform of natural science in Iceland. The reports were under the influence of the major curricular reform originated in Western education in the mid 1950s and the direction was conclusive:

> … the main purpose of physics and chemistry instruction in lower-secondary schools is to prepair students for living and working in a changing society so that the ordinary citizen will neither be frightened by science nor worship it in blindness. He should realize that the cause of most natural phenomena is normal and that the application of scientific working methods is important in order to understand and have some control of our environment (Menntamálaráðuneytið, 1968, p. 8).

The booklet on physics-chemistry covered 15 pages, starting with general aims stressing knowledge and understanding of essential topics in physics and chemistry, practicing measurement and systematic observations, focusing on applying knowledge to resolve new problems, interpreting results from observations and discussing results. Then there are statements of what students in lower-secondary schools are expected to know and be able to do upon completion of learning physics and chemistry. It was classified into seven categories: Measurements of time and distance, properties of matter, compounds and the atom theory, thermodynamics, mechanics, wave theory and electronics. The last chapter in the curriculum booklet is labelled 'instruction methods', suggesting that students work in groups when solving problems and doing experiments. It is considered important that students compare their results and discuss variations in outcomes.

According to the above analysis, the 1976 curriculum was characterized by the instrumental purpose as was the 1960 curriculum, actually with a more rigorous body of knowledge and ties to further academic science learning. Students need to acquire a great deal of scientific knowledge and skills although the 1976 curriculum does not adhere the teacher-as-transmitter-of-knowledge model of science education. Learners are conceived as neophytes in a hierarchical community of the academic disciplines, but their learning should resemble the work of the scientist: 'The difference is in degree, not in kind. The schoolboy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else' (Bruner, 1966, p. 14). Teaching involves shaping behaviour, where learners are the raw material to be shaped. Although there are no clauses about assessment specifically, the structure of the curriculum is in favour of the view that assessment involves gathering objective data about the achievement of learning. Assessment is considered as means to confirm achievement of learning, informing the student and his or her parents, authorities and schools on the next school stage about achivements of learning.

Although the 1976 curriculum suggested group work and enquiry learning or discovery learning, altogether it features an instrumental, subject-oriented model of learning.

1989

The 1989 curriculum was issued in one book where the science part covered 10 pages of 196 (5%). The title was the same as in 1976, *Aðalnámskrá grunnskóla* (*The national curriculum for compulsory schools*). It was in effect for 10 years from 1989 to 1999, built on the Educational Acts from 1974, 1991 and 1995. The first part of the book covered general aims for compulsory schools, and chapters about the role of compulsory education, about schools as institutions of a developing society, about theories of child development, learning environments and the integration of school subjects: 'Systematic integration of two or more school subjects incurs that subject matters are examined from different perspectives and should thereby provide a deeper understanding and a more holistic view ... Thematic learning applies knowledge and methods from different school subjects, and thereby the boundaries between subjects are blotted out' (Menntamálaráðuneytið, 1989, p. 32).

The second part of the curriculum was divided into chapters according to the names of the school subjects to be taught in alphabetic order. The chapter on nature study, labelled *Nature study (physics, chemistry and biology)* (i. *Náttúrufræði (eðlis-, efna- og líffræði)*) started with a general discussion about nature study as a school subject, including a philosophic discussion about the role and nature of science, its connection with daily life and other educational disciplines. Then there is a short passage on the main goals, where the main focus is on 'sympathy towards life, nature and the environment ... critical attitudes towards nature conservation ... inquiry learning ... working together with other students on science projects ... exploring big ideas and whole contexts in nature and finally: ' know and understand basic theories in physics, chemistry and biology and the impact of those sciences on our way of living and our world view.

According to the above analysis, the 1989 curriculum was characterized by the liberal purpose rather than the instrumental purpose and the social meliorist perspective was not far off, because of the tendency to urge critical thinking and see teaching and learning as acculturation into an environmental friendly society: 'Natural science and technology are among the most important preconditions for our way of living, but also what endangers our future most of all' (Menntamálaráðuneytið, 1989, p. 106).

Although the 1989 curriculum specifies the acquisition of scientific knowledge and skills to a certain extent the goals and objectives are too open-ended and ambiguos to be understood as instrumental or subject oriented, and can not at all be interpreted as scholar academic or mental disciplinarian. On the other hand there are many interesting recommendations about the process of learning and teaching, using group discussion, relating to students' own experiences and prior ideas, using the natural environment of the school as subject matter, and practicing hands-on learning through direct contact with natural phenomena.

Discussion

The first issue of concern that needs further discussion is the limited space natural science has in the official curriculum, no matter whether it is characterized by the liberal or the instrumental purpose. As argued before, science is an expanding field in the whole curriculum, a mixture of different kinds of visions and educational aims, rather than a rigidly defined school subject. An OECD report about the Icelandic education system (OECD, 1987) affirmed that Icelandic curricula differed markedly in the balance of subject areas from what was common in other countries: 'The crux of this difference is in the large amount of time devoted to language learning, both of the

mother tongue and of two foreign languages, which of course limits other areas such as social studies, history beyond Icelandic history, and science' (OECD, 1987, p. 23).

Conceiving natural science as an expanding field with limited space in the compulsory curriculum we need to pay attention to what Elliot Eisner termed the 'null curriculum' (1985), i.e. the elements that we are forced to decide not to teach, thereby giving students the notion that these elements are not important. They inevitably get the message that the content or processes involved are not significant enough to be included. Ignoring such elements 'is not simply a neutral void; it has important effects on the kinds of options one is able to consider, the alternatives that one can examine, and the perspectives from which one can view a situation or problems' (Eisner, 1985, p. 97).

Another facet of this very problem is an overcrowded curriculum. Stinner and Williams (2003) phrased this situation as the school science curriculum becoming an ever more 'crowded place', appearing alternately as 'a carefully-tended garden' to some people, and 'a weed patch of trivia' to others: '...someone was always coming up with some new scientific information that everyone should know, and few people ever suggested removing anything'. If perpetual impulses for curricular changes in science education have become so common 'as to be an orthodoxy' as Donnelly and Jenkins (2001) described it, then the transformation of the science curriculum over time may appear as recurring cycles of ideals. This little study certainly indicates that ideologies such as the scholar academic, the social efficiency, the learner-centered and the social reconstructionist do seem to appear as recurring cycles.

But we must bear in mind that changes within the culture of education such as the transformation of the science curriculum do not take place in a vacuum. We need to take into account external factors that affect curriculum transformation, i.e. technological, economic and social structures, which inevitably 'set parameters and possibilities for internal change' (Goodson, 2005). So progress does happen, 'we can not step into the same river twice'.

Finally it should be emphasized that when the curriculum in natural science is viewed from an international perspective, it has evolved with respect to the above delineated ideologies in its own particular manner, featuring the teacher-as-transmitter-of-knowledge model as in the 1960 curriculum, discovery learning model related to abstract scientific concepts and viewing the pupil as a scientist as in the 1976 curriculum, and finally a sort of socio-cultural model, focusing on the integration of science with other subjects, societal issues and environmental issues as in the 1989 curriculum. Other focal points in the history of science education, such as scientific literacy, social constructivist learning, STS (science-technology-society) and ESD (education for sustainable development), were certainly not far off in the official curricula in 1960, 1976 and 1989 though they had not yet been brought up literally in the curriculum texts before the end of the twentieth century.

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