

# CONSIDERING LIBERAL AND HUMANISTIC VALUES IN SCIENCE EDUCATION CURRICULUM

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## Abstract

*This paper examines current changes in the value-base of science education curricula. One of the theoretical instruments used to describe values in science education is the notion of “curriculum emphases” developed by Roberts (1982). The evolution of values in school subjects goes hand in hand with general value-shifts in society that Bauman (2000) describes as ‘liquid modernity’ and ‘liquid life’. Kress (2000) argues that whereas the previous era required an education for stability, the coming era requires an education for fluidity and instability. Similar arguments for the “appreciation of irreducible uncertainty and multiple perspectives” in science education are also proposed by Gray and Bryce (2006). The present paper suggests a conceptual framework for considering curricular values in science education and describes currently shifting priorities in curricular values towards more ‘light’ and ‘soft’ science education. It is also argued that the democratic science education curriculum should provide space for students to pursue liberal education values as well as humanistic values. This also poses new challenges for science teacher education.*

**Key words:** *uncertainty, complementarity, curriculum emphases, methodological principles.*

## Introduction

This paper discusses changes in science education curricula values that are taking place in Sweden and other countries around the world. The transformation of values in school curricula goes hand in hand with general value-shifts in society. Currently, these shifts can be described, using Zigmunt Bauman’s words, as a move towards ‘liquid modernity’ and ‘liquid life’ (Bauman, 2000). According to Bauman (2000), in post-modern ‘individualised society’ values become more light and fluid, structures become more unstable, and the patterns of dependency and interaction between individuals tend to be liquefied.

In the western world, the individualization of society is characterised, in particular, by transference of responsibility for professional action and organisation of life from the state and institutions to individuals. This also means that “the burden of pattern-weaving and the responsibility for failure falls primarily on the individual’s shoulders” (Bauman, 2000, p. 8). In the Swedish educational context this can be seen for example in a shift of responsibility for curriculum development from the state to the teacher, and in turn a shift of responsibility for achieving results/learning outcomes from the teacher (school) to the learner. Swedish curricula emphasise the active agency of learners already at the lower school grades. The individual science teacher has the freedom (within the frame of his or her own competence and values) to prioritise what subject knowledge and values to focus

on, what messages within and about science to communicate and how to motivate students. Students are encouraged by the curriculum to exercise an influence over the organisation of teaching/learning in all its instances. All this makes science teaching in different schools and even classrooms very diversified and difficult to analyse.

The main purpose of this paper is to suggest a methodological approach and a conceptual framework for reflecting on curricular values in science education and describe the current shift in priorities in curricular values towards more 'light' and 'humanistic' science education. It is also argued that the modern science education curriculum should provide space for students to pursue liberal educational values as well as humanistic science education values. The readiness of the teacher to meet the students' pursuit of liberal education in the science classroom is also problemized.

## Work methodology

This paper is a result of reflection on literature studies and on my personal experience of working in science teacher education in Sweden and other countries over the last decade. The issue of values arises naturally in any educational reform and curriculum project. Recently, explicit discussion on this topic re-appeared in the field of science education with the publication of the book "The re-emergence of values in science education" edited by Debbie Corrigan, Justin Dillon and Richard Gunstone (2007). My personal interest in this issue is grounded in private experience of work in and with science education in different cultural contexts that unsurprisingly led to comparisons and reflections on value-laden choices that different curriculum projects opt for. I felt the need for analytical tools for such reflections that can help in the analysis and understanding of curriculum trends.

The development and use of any tool is based on people's personal background and aims to satisfy certain needs. My physics background leads to the application of methodological principles developed in physics to science education, as shown below. Dick Gunstone drew my attention to the Douglas Roberts (1982) paper on "curriculum emphases". I heard that Roberts himself considers this paper (Roberts, 1982) already outdated, but I suspect that good ideas have a value and life beyond the intention of their creators. Structuring and adapting Roberts' theoretical constructs to reflect on current curricular trends seems to be productive.

The ideas of this paper were also tested with colleagues at the department during seminars and the regular common "coffee-breaks" (*fika*) that are a natural part of Swedish academic life. People have a chance to meet and discuss their feelings and visions about life and current teaching twice a day for thirty minutes. These informal meetings have great value for solving many academic problems and generating new ideas. Critical insights are much more easily expressed in the informal environment than in a formal seminar setting. Thus, the literature analysis, reflections on my personal experience and colleagues' critical considerations constituted the main basis for my work on this paper.

## Considering uncertainties and complexities in science education

Bauman's description of contemporary society in terms of fluidity, lightness and individualisation also reflects the situation with curricular values. Schools have to deal with a variety of quickly changing individual priorities and values. However, researchers and curriculum developers often focus only on one "currently prioritised" set of values and try to offer one "best solution" for existing problems. Such a monotheistic approach is typical of western intellectual tradition in general (Ben-Dov, 1995), when only one perspective is used to see the phenomenon. New approaches allowing for at least dualistic (or pluralistic) perspectives for the analysis of current trends and values in education seem to be needed.

Some fundamental principles developed in physics can contribute to the formulation of a methodological approach for the analysis of science education values. In physics, major epistemological changes were introduced with the principle of uncertainty discovered by Werner Heisenberg in 1927. This principle pointed out inherent uncertainties in our understanding of and thinking about the world. For example, the impossibility of knowing the exact position and velocity of a particle at the same time; the more precisely position is identified, the less exact will be knowledge of the particle's velocity.

Another important principle suggested the same year by Nils Bohr was complementarity. According to Bohr, we have to accept that an object can reveal different properties in different circumstances that can be explained by rather incompatible theories. For example, an electron can behave in some experimental situations as a particle and in others as a wave. So, wave theory (describing diffraction of electrons) is valid in one case and kinematic descriptions (of electron trajectories) in the other. These theoretical descriptions (which are quite contradictory) complement our understanding of electrons. Bohr suggested the possibility of using this principle in other fields of science than physics (Ben-Dov, 1995).

These principles also point out the importance of considering the strong influence exercised by observer on the studied object. The observer always changes the conditions and behaviour of the observed object. This is important to have in mind when we design experiments and analyse the results above all in educational research. Thus, following Bohr's line of thought it is possible to suggest that uncertainty and complementarity can be considered as general epistemological principles applicable not only when studying physical objects but also when studying social objects.

The application of these principles seems relevant in our post-modern 'fluid world' in the same way that they were introduced to substitute classical mechanistic world-view by a stochastic description of the modern world, using for example a quantum mechanic theoretical perspective. There are several authors that encourage us to reflect upon the uncertainties and complexities of the modern world in curricular work in science education. According to Kress (2000), we can no longer accept an epistemological position that knowledge about the world is stable, existing just outside what we can and should acquire. Kress (2000) argues that whereas the previous era required an education for stability, the coming era requires an education for fluidity and instability. Such a curriculum, he calls it a "design curriculum" requires considerable flexibility and open-endedness about subject aims. It sees the learner as fully agentive with "individual dispositions oriented towards innovation, creativity, transformation and change".

Strong arguments for the "appreciation of irreducible uncertainty and multiple perspectives" in science education were also made by Gray and Bryce (2006). These authors discuss the importance of openness and flexibility in science education curricula. The actual Swedish curriculum was developed following this trend. It is illustrated in the text below.

#### In-built flexibility in the Swedish curriculum

Taking into consideration the rapidly increasing information load, complexity and diversification of the world, it is necessary for school curricula to become less prescriptive and rigid. Modern curriculum design opens up greater possibilities for teachers together with students to decide what and how to study. In Sweden, the recent curriculum called LPO94 for compulsory school and LPF94 for gymnasium was introduced in 1994.

The new curriculum states the school's fundamental values and basic objectives and guidelines (see <http://www.skolverket.se>). Objectives are presented in the form of certain goals for school activities. There are two distinctive categories of goals:

- *Goals to strive towards* specify the orientation of the work in the school. They specify the qualitative development desired in the school.
- *Goals to be attained* express the minimum levels pupils should have attained when leaving school. The schools are responsible for ensuring that pupils are given the opportunity to attain these goals.

LPO94 (as well as LPF94) defines goals leaving the identification of work methods up to each school and the individual teacher. Curriculum does not prescribe what subject to teach at what grade or how much time should be allocated for different topics. This is decided by each school according to the staff's collective view on what is the best way to attain curriculum goals. Local school plans are developed for each grade and subject. These plans are used as general steering documents for organising everyday teaching/learning.

The Swedish curriculum relies very much on the teacher's professionalism. It assumes that the individual teacher will exercise his/her professional competence and judgement in selecting what, when and how to teach. There are no central prescriptions as to what to do and how to attain the goals.

Goals formulated in the curriculum are concretised in the syllabi. The Science syllabi present, firstly, the general goals for science studies that schools should strive towards, and then translate them into goals that pupils should have attained by the end of the fifth and ninth years in compulsory school and at the end of gymnasium studies.

An example of what the hierarchical structure of goals looks like in the text of science syllabi is presented below. The general goals to strive towards are presented in three categories:

- concerning nature and Man,
- concerning scientific activity,
- concerning the use of knowledge.

For the sake of simplicity, only the first category goals will be followed in the syllabi, i.e. what is to be attained in natural sciences and physics by the end of compulsory school.

**Table 1. The goals "concerning nature and Man" in the Swedish National curriculum LPO94.**

<i>The school in its teaching of science studies should aim to ensure that pupils</i>	
Goals to strive towards (science)	Goals to be attained (science)
<ul style="list-style-type: none"> <li>– believe in and develop their ability to see patterns and structures which make the world understandable, as well as strengthen this ability through oral, written and investigatory activities</li> </ul>	<ul style="list-style-type: none"> <li>– have a knowledge of the universe, the earth, life and Man's development,</li> <li>– have an insight into how matter and life is studied at different levels of organisation,</li> <li>– have a knowledge of the cycles of nature and the flow of energy through different natural and technical systems on the earth</li> </ul>
Goals to strive towards (physics)	Goals to be attained (physics)
<ul style="list-style-type: none"> <li>– develop their knowledge of fundamental concepts in physics in the areas of mechanics, electricity and magnetism, optics, acoustics, heat, as well as atomic and nuclear physics,</li> <li>– develop their knowledge of energy and energy forms, their transformation and properties, as well as society's supply of energy,</li> <li>– develop their knowledge of different kinds of radiation and its interaction with matter and living organisms,</li> <li>– develop their knowledge of the world view of physics on the basis of astronomy and cosmology</li> </ul>	<ul style="list-style-type: none"> <li>– have an insight into how the planets rotate around the sun, as well as how the earth and the moon move in relation to each other, and be able to relate the calendar and seasons of the year to these movements,</li> <li>– have an insight into basic meteorological phenomena and contexts,</li> <li>– have an insight into technical applications of electricity circuits and permanent magnets,</li> <li>– have an insight into the fundamentals of dispersion of sound, hearing, as well as the properties of light and the functions of the eye,</li> <li>– have a familiarity with narratives about nature, which are to be found in our own culture and that of others</li> </ul>

The above table 1 text illustrates that the syllabi formulations are quite open for interpretation. The teachers thus have the possibility to exercise a lot of freedom in realising these goals and defining what level of demands they should put on students knowledge and skills. This is not an easy task for the subject teacher who is overloaded with many pedagogical and administrative tasks. This means that, in practice, the textbooks are used to define what and how to teach (also with the help of the teachers' guide that accompanies the textbook). Schools can choose different textbooks but after a choice has been made teachers and students work through the chosen one also using additional teaching materials.

## A conceptual framework for looking at curricula values

One of the possible conceptual frameworks for analysing curricula values in science education is that of “curriculum emphases” developed by Douglas Roberts. According to him (Roberts, 1982), a curriculum emphasis in science education is a coherent set of messages to the student *about* science (rather than within science), that can be communicated explicitly and implicitly. These ‘emphases’ communicate certain values or views about why learning science is important.

Roberts (1982) identified seven curricula emphases. It is possible to organise them into four pairs (along four dimensions) adding one more emphasis that can be called *liberal science education* that will be discussed later. The first term in each pair reflects a more ‘rigid/classical’ view of science and the second one a more ‘fluid/modern’ one.

However, in an intended (written) curriculum, we can seldom see a focus on just one emphasis or set of associated curriculum values. There are several that will be articulated in some form and considered as complementary. However, in implemented curriculum (classroom practice) a particular emphasis and associated values can be identified in a more distinguished form. The table 2 below presents curriculum emphases adapted from Roberts (1982).

**Table 2. The analytical structure of curriculum emphases in science education.**

Emphases (focused values) in science education curriculum	
1) academic - practical dimension	
Solid Foundation - instruction to facilitate the student's understanding of future science instruction. The message communicated: learn basics now to get more advanced knowledge later on. It is a preparation for future academic studies.	Everyday Coping - science is an important means for understanding and controlling one's environment – be it natural or technological. This emphasis stresses “functional understanding” of scientific principles. Learn about usefulness/ application of scientific knowledge in practical situations!
2) institutional – individual dimension	
Structure of Science - how science functions intellectually in its own growth and development. Learn about the nature of science!	Self as Explainer – the student as an active agent. Focus on making sense for oneself.
3) product - process dimension	
Correct Explanation - stresses science products/ knowledge. Encourages learning content knowledge!	Scientific Skills Development - developing fundamental skills required in scientific activities. Process is more important than product! Learn skills of enquiry!
4) liberal - humanistic dimension	
Liberal Science Education – directed towards the enlargement of the mind, not especially to professional or technical needs. Knowledge for the sake of knowing. Learning and understanding has a value in itself. Learning for self-development.	Science, Technology and Decisions – focus on differences between technocratic and social and individual value-based choices in decision making. The STS movement is a typical representative of this emphasis. Focus on socio-scientific issues and humanistic science education.

This analytical structure (table 2), based on an adapted Roberts (1982) categorization, gives us a tool for reflection on priorities in the science curriculum. An analysis of the Swedish curricula materials for gymnasium (physics textbooks and steering documents LGY70 and GY2000 valid in the 1970's and after year 2000) shows the following changes with time (Popov, 2007):

- Less focus on content but more on processes of science

- Less text and formulas in textbooks but more pictures and illustrations
- Less calculation tasks but more discussion questions
- Less “deep physics” but more technical applications.

Apparently, there are shifts in curricular emphases from those presented in the left column of the table to those in the right (rigid - soft). In curricular reforms that have taken place over the last decades *soft destinations* seem to be consequently promoted by curriculum developers. An analysis presented by Glen Aikenhead (2006) shows strong current international trends that focus on humanistic values and work-forms in science education, such as:

- Debating and discussing
- Playing and doing hands-on activities
- Analysing and position taking
- Exercising critical thinking.

Meanwhile, liberal values and “hard science” are falling out of focus in modern science education curriculum development projects. This issue will be discussed below.

### Liberal science education

Traditionally, studying science was always a part of liberal education. According to the Webster Dictionary definition it is education that enlarges and disciplines the mind and makes it master of its own powers, irrespective of the particular business or profession one may follow (<http://www.webster-dictionary.net>). Liberal education assumes that students engage in learning for the sake of enjoyment of learning and knowing. The ideals of liberal education can be seen in the OECD forum curriculum recommendations for increasing interest, motivation and competence in science studies amongst students (OECD, 2006). These include among others:

- Transmitting the excitement of science from the teacher to the student.
- Exposing students to the *joy* of discovery.

These recommendations emphasise liberal values of learning science just for the joy of learning it. Some students might experience the excitement of discovering scientific explanations of the structure of the Universe, learning about quarks or global phenomena in the Earth etc, and this could be enough for them to be highly motivated to study science. However, showing the students the possibility of loving science just for its beauty, logic and intellectual challenges no longer seems to be common among teachers. The OECD (2006) attributes this problem to the fact that many teachers themselves do not have a sufficient level of comfort and confidence about science and maths.

However, as Crawford (2005) stresses, the private intellectual pleasure of the student in solving intricate physics problems, when after struggling with frustrations and finally after hours of hard rumination getting the right answer, is most probably not a good motivation for studying science for the majority of students. Thinking ontogenetically, it is possible to recall that most small children are curious about physical phenomena and their explanations. They get personal satisfaction from knowing how things happen. Many of them like to think hard and can ‘work hard’ in the learning process. However, this potential for intellectual work and patience in learning disappears if is not stimulated and practiced. As physical activities shape the body, intellectual activities shape the mind. Learning science demands hard activity by the mind and can provide real intellectual gratification in the form of understanding. But, it is not possible for everybody to get success in science, in the same way that not everybody can succeed in sport or music.

Teachers have limited possibilities (and abilities) to provide appropriate (in Vygotsky’s terms of the zone of proximal development) intellectual challenges for every student in the class. But the teacher can trigger the student’s interest. Similar situations exist in other fields of human activity. For a long time, Sweden has been successful in “producing” famous sportsmen and musicians. A basis for succeeding in these fields is laid down by many dedicated teachers in compulsory schools and developed further in specialised (state and municipality supported) sport or music institutions (formal and informal).

Similarly, the ordinary school education can not lay the ground for being a good scientist for every

student. At best, teachers can challenge and generate an interest in “pure” science studies for some students, but not all. Greater possibilities to prepare for future sport, music or science careers (and to give young people the possibility of experiencing the joy of the corresponding activity) exist in specialised schools/classes or other specialised institutions like sports clubs, music schools, science clubs, etc. In some schools, enthusiastic teachers can engage many students in science studies (for example, in Swedish national physics competitions teams from the same schools usually take leading positions many years consecutively). However, broad and stable success can not be assured without the work of specialised institutions supported by the state, as in the case of music and sport.

It is also possible to make a remark here about the role of parents in discovering and triggering children’s interest in different activities. Apparently, adults have less chance and possibility to realize and develop a child’s interest in academic studies and “solving science puzzles” in the home environment than they have to inspire their music or sport activities. The role of the science teacher in awakening and stimulating the child’s interest in science cannot be overemphasised.

Should learning science in school be hard work or active leisure? Many extra curricular activities in existing science museums and centres in Sweden are organised under the banner “science is fun”. Curriculum innovations also lead teachers to work in the direction of making learning science fun and doing science activities as an exciting leisure activity. However, Swedish curriculum LPO94 also states that “Education should be adapted to each pupil’s circumstances and needs. Based on the pupils’ background, earlier experiences, language, and knowledge, it should promote the pupils’ further learning and acquisition of knowledge”. Unfortunately, striving to implement humanistic science education, schools often forget the needs of the children who are interested in pursuing liberal science education values. These children see intellectual achievement as a goal in itself and have internal motivation (self-challenge) to study tough science.

Partly, the interests and needs of these children can be satisfied by using new learning resources like web 2.0, blog, wiki, podcasting or YouTube, that open new possibilities for knowledge development and acquisition. There are also expectations that video games can redefine education. The games can teach skills of analytical thinking, team building, multitasking and problem solving under duress. Currently, these technologies are common in the lives of Swedish students. However, the role of a competent teacher will always be irreplaceable in creating a new generation of science-educated people.

Unfortunately, Swedish teacher education takes rather a minimalistic approach in providing prospective teachers with deep subject knowledge and skills to develop students’ abstract and logical thinking (or theoretical thinking, in Vygotsky’s terms). The focus is rather on varieties of practical acquisition and uses of knowledge. Prospective teachers’ interests in developing methods of advancing students skills of abstract-theoretical thinking in science education almost do not exist. This partly reflects the absence of teacher educators’ interest in these issues. Here, the principle of uncertainty can explain the situation. The more focused teacher educators (and teachers) are in humanistic values in science education the less clearly they see liberal education values (and see the necessity to work with them).

## Conclusions

Obviously, teacher education does not make fully-fledged professionals; it leads students to the point where they can begin their profession. However, Swedish science teacher training for compulsory school focuses more on pedagogy than on subject knowledge. Students receive tools to be reflective primarily in educational sciences rather than in natural sciences. It is possible to argue that for the school teacher it is easier to deepen general educational competence through self-study and in-service training than to independently develop a solid science subject base. In Sweden, prospective teachers are handicapped in relation to their task of teaching students who are interested in science. If a student is not interested in socio-scientific issues or everyday life applications of science, but wants to satisfy his/her own curiosity and just enjoy solving “science puzzles” (learning for the sake of learning) many teachers do not have enough competence to help such students. She or he is not trained for that and may not even see the problem. Focussing on one thing (humanistic values) people tend to miss another one (liberal values).

The challenge of finding a place for liberal as well as humanistic values in science education is not easy to meet in the near future without shifts in curriculum policy and strong informal science education. Teacher education also has limited opportunities to provide a deep knowledge of science to students without

extra economic support from the government. Teaching small classes (not many students in Sweden want to become science teachers) is not economically feasible if the number of contact hours is not reduced. As the OECD (2006) points out, “governments and relevant institutions should provide adequate resources for teacher training and classroom activities. Flexible, more attractive curriculum structures with updated science and technology content should be devised”.

Flexibility in curriculum design is important but of no less importance is the teachers' knowledge and skills in how to satisfy the cognitive needs of “weak” students as well as the “strong” ones. Here, the principle of complementarity also works, nobody knows when practical relevance (or showing the humanistic side of science) and when abstract knowledge (or cognitive challenge) can trigger students enthusiasm for science. In different circumstances and for different people both of these curricular elements (set of values) can be vital.

The approach of complementarity rejects clear-cut answers (based on “universally valid sets of principles”) to existing problems. For example, science education for everyday life (Aikenhead, 2006) can not be the only solution to attracting students to science studies. The modern science education curriculum should provide space for students to pursue humanistic as well as liberal education values.

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