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Integrated and Subject-specific.

An empirical exploration of Science education in Swedish compulsory schools.

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Abstract

This thesis is an explorative experimental study in two parts of different ways of organising Science education in the Swedish context. The first study deals with the question if students attain higher scores on test results if they have been working with integrated Science compared to subject-specific Science i.e. Biology, Chemistry and Physics. The second study concerns the similarities and differences between integrated Science education and Science education in Biology, Chemistry and Physics, especially in the teaching organisation.

The introduction describes the nature of integrated curriculum, what integrated learning is, issues about integrated Science education, in what way integration is carried out, between subjects or within subjects, what the opposite to integrated Science is (here named as subject-specific science education) in the Swedish context and what the Swedish curriculum has to say about integrated Science. Previous studies in integrated curriculum looking at students' results are referred to, and it is argued for the use of the OECD's PISA assessment instrument in this study.

The thesis consists of two studies, one quantitative and one qualitative, within the above framework. The quantitative study is an attempt to find differences in scores on students' written results on a large-scale assessment in scientific literacy between students studying in different organisations of Science education. The qualitative study is an attempt to describe differences at classroom level between integrated Science and subject-specific Science. This gives a quite rich description of four schools (cases) in a small town and how they organise their teaching integrated or subject-specific.

No differences in students' results between different Science organisations were found in the quantitative study in this thesis. Possible explanations for the lack of differences in students' results are discussed in the article. An additional investigation that attempts to test the variable used in the quantitative study is carried out in the thesis, with an attempt to sharpen the teacher organisation variable. This is done to find out if it is possible that there can be found differences with the sharpened variable.

The qualitative study gives a glimpse of some differences in the implemented curriculum between schools working with integrated Science education and a school that works subject-specifically. The teachers do the overall lesson plans in different ways according to which organisation according to integrated or subject-specific Science they work with. When asked in a survey what kind of Science organisation they have, students from the four schools studied answered differently between schools and also, sometimes, within the same school. A further analysis of this second study is carried out by defining a conceptual framework used as structure and a possible explanation for differences between students' views and teachers' views on the organisation of Science education. This latter analysis tries to give an enriched description in mainly the two levels of the implemented and attained curricula, and tries to discuss the difference in students' attained curriculum.

A final discussion concludes the thesis and concerns an elaboration of the results of the thesis, problems with the main variable involved in the two studies and the possibility that the teacher actions effects also the magnitude of students' achievement on tests.

List of articles

Article 1

Using hierarchical linear models to test differences in Swedish results from OECD's PISA 2003: Integrated and subject-specific science education *Åström, M. and Karlsson, K.-G. accepted by NORDINA for publication*

Article 2

Integrated and subject-specific Science education: Teachers' and students' views. *Åström, M. and Karlsson, K.-G. Manuscript*

1. Introduction

Skilful students, and good education, how can a specific school attain this? The organisation of education is supposed to be important. But is it? And how important is it? Can it be seen on the students' score when comparing students from different Science organisations? This licentiate thesis consists of two studies, one quantitative and one qualitative. Both studies are done to explore the concepts of integrated Science education as opposed to subject-specific Science education. The first quantitative study deals with students' score on a written assessment in relation to integrated and subject-specific Science. The second study describes integrated and subject-specific Science in four compulsory schools in a small town in Sweden.

1. Rationale

1.1 The nature of integrated curriculum and trends towards integration

The word integration in the Swedish National Encyclopaedia (Nationalencyclopedin, 2002) is defined as fusion in to a whole, or arrangement as a natural part of a whole. It comes from the Latin word 'integrare,' which means to restore to an unspoiled whole. The word integrated curriculum has a long history in Anglo-Saxon research. It has been possible to search for it in the ERIC thesaurus as early as 1966. According to ERIC, integration is a 'systematic organization of curriculum content and parts into a meaningful pattern.' A related term, unified studies curriculum, was registered in 1980 and is defined as 'Curriculum designed to integrate an educational program by eliminating the traditional boundaries between fields of study and presenting them as one unified subject'. In the Webster's online dictionary the word "to integrate" can mean four things: 1) make into a whole 2) open (a place) to members of all races and ethnic groups 3) become one, become integrated 4) calculate the integral of (in mathematics). In this thesis integrate means making into a whole in science education in schools. How the whole and the parts are interacting with each other is not the same in the different texts that are quoted. Different authors have different views of how integration could be made. I will try to make some distinctions between the different views of integration in my thesis, but not in the manner of whole and parts, but within the difference between integrated and subject-specific curriculum to be a useful interpretative tool for the division of my work and studies in this thesis.

The nature of the integrated curriculum has been discussed by many authors over a long period of time, most intensely during the 1960's, although there was work in this field as early as the beginning of the twentieth century. This study deals with the works of Bernstein, Hirst and Carson. Bernstein and Hirst discuss two contrasting types of curriculum, integrated on the one hand and on the other hand organisation that go under different labels depending on the author. Bernstein writes about the different form as collection curriculum and Hirst mentions traditional curriculum, while Carson does not discuss alternative forms to the liberal curriculum he writes about.

Bernstein writes about two types of curriculum: collection or integrated (Bernstein, 1975). He talks about the content relationship. If contents are insulated from each other the relationship is closed. If insulation between various contents is reduced, the relationship is open. Bernstein explains this difference as follows:

> 'Strong insulation between contents pointed to a collection type, whereas reduced insulation pointed to an integrated type' […] '*Classification thus refers to the degree of boundary maintenance between contents*.' (p. 88, emphasis in original) […] 'Strong framing entails reduced options; Weak framing entails a range of options. *Thus frame refers to the degree of control teacher and pupil possess over the selection, organization, pacing and timing of the knowledge transmitted and received in the pedagogical relationship*' (p. 89, emphasis in original). […] 'Where classification is strong, the boundaries between the different contents are sharply drawn. If this is the case, then it pre-supposes strong boundary maintainers. Strong classification also creates a strong sense of membership in a particular class and so a specific identity. Strong frames reduce the power of the pupil over what, when and how he receives knowledge, and increases the teacher's power in the pedagogical relationship. However, strong *classification* reduces the power of the *teacher* over what he transmits, as he may not over-step the boundary between contents, and strong classification reduces the power of the teacher *vis-à-vis* the boundary maintainers' (p. 89-90, emphasis in original).

Bernstein's factors of time, form, classification and frames, and especially the strong and weak classification of the boundaries is used as a model to view the realisation of Science education in classrooms in study 2 in this study (Bernstein, 1983). Later Bernstein has extrapolated the consequences of differences in strong and weak classification to students from different social class (Bernstein, 1996). The idea of strong and weak classification has been unchanged through Bernstein's work. In this thesis the later work of Bernstein is not taken into consideration, since the division of the frames for organisation is the idea used in the present study. Schools in Sweden all have the same goals but since schools retain a level of autonomy implementation varies from school to school. The schools have different practical and social frames which create differences in teaching organisation.

Hirst and Peters writes about integrated curriculum (Hirst & Peters, 1970). They describes traditional, tough-minded teaching that stresses the importance of knowledge with a clear division of subjects, numerous examinations, formal class instruction and the maintenance of discipline through punishment. He contrasts this to a tender-minded teaching where children learn to learn in a curriculum that reflects children's interests and needs in a combination of group projects and individual activity. Subject division is seen as an artificial impediment to learning and examinations are viewed as promoting unwished-for rejection and failure (ibid, p. I).

Carson writes about 'Liberal education, or the education of people for liberty, equips people to think, to see alternatives, to analyse, compare, synthesise and contrast, to criticise and to make morally and intellectually defensible judgement' (Carson, 1998), p. 1004-1005). Carson endows liberal education with aspects similar to constructivism in that he claims it enables students to both learn and judge their knowledge.

In conclusion Carson writes

> '…science education must address not only the transmission of scientific facts, and the cultivation of scientific praxis, but the whole range of social, cultural and intellectual

> issues. The demands currently placed on science education by this expanded agenda would seem to argue in favour of a contextualist approach to science teaching. This approach is also supported by current thinking in educational psychology, especially the constructivist theory obtained from Piaget's work' (ibid p. 1013).

Power, politics and ideology are part of the debate on curriculum. These factors explain the forces moving for and against integrated curriculum. The debate involves various actors and interests in Sweden (Wennberg, 1990). An early writer in the field of ideology in teaching outside Sweden is Musgrove (1973), who has written about integrated and specialised curricula and power. Arguing for subject specialisation, he writes:

> 'The argument for subject specialization in the first half of this century was powerful, and it prevailed. [...] At root the argument was aesthetic: it was an argument about good taste. And good taste is a matter of selection, exclusion, constraint, discrimination.' (Ibid, p. 3) 'But the philosophers of Fourth Century Athens and contemporary Britain were also interested in specialization in a way which has some relevance to my theme. Their interest has been in labelling and the classification of phenomena as an aid - indeed a prerequisite - of efficient and systematic thought.' (Ibid, p. 4)

Musgrove (Musgrove, 1973) sees boundaries and the division of labour as reasons for the development of specialized curriculum and integrated curriculum. He refers to Durkheim's discussion of the division of labour and in contrast points out that 'Rousseau's prescription was for individual self-sufficiency and social anarchy.' Musgrove considers it important to distinguish between areas that can and those that cannot be integrated. Integration takes on pathological forms in two areas: industrial production and education. In industrial production Musgrove argues that the division of labour promotes interdependence strengthens the bonds that unite men, although it can also become anomic or pathological. In education, Musgrove argues that

> 'We see the relevance of other subjects when we have reached the boundaries of our own and push through them. It is true that the most exciting and creative work is occurring today on the boundaries between subject areas; but this is very advanced work that we are talking about. At lower levels, interdisciplinary work is more likely to lead to naïve and inappropriate transfer of concepts.' (ibid, p.7)

Musgrove argues that integration should take place in the early school years and in advanced Science learning. He worries that interdisciplinary work (i.e. integration in this thesis) can lead to superficial learning. Musgrove maintains that there are special difficulties with integration at the lower and upper secondary school levels.

In Sweden, Riis has studied the curriculum focusing on integration in the documents of school changes (Riis, 1985). Riis concludes that the ideology of integrated curriculum in the early curriculum documents was taken from religion (the Christian idea that the human is one). In later documents (1960 and later), the ideology behind the integration was democracy and change.

1.2 Integrated learning

Integrated learning appeared as a search word in the thesaurus of 1980. Integrated learning arises from an integrated curriculum. Presently it is not possible to search for the word integrated learning; the thesaurus uses instead the term integrated activities. Integrated activities are defined in the thesaurus as 'Systematic organization of units into a meaningful pattern'. A related term is learning activities, defined by thesaurus as 'Activities engaged in by the learner for the purpose of acquiring certain skills, concepts, or knowledge, whether guided by an instructor or not'

In research literature writers often describe learning in two ways (Lundgren, 1979). In later educational theories a third, elaborated way of learning is discussed. The different ways of learning is first transmission, in which the teacher presumably knows everything worth knowing and transmits this knowledge to the student. This is related to the behaviouristic branch of research in psychology. In Carson the behaviouristic work is described as '… instrumental, vulgar and doctrinaire.' (Carson, 1998), p. 1007). The second way of learning sees the teacher as constructing an environment in which the student constructs knowledge. This is more like cognitive science, a reaction to behaviouristic psychology (Stenlund, 2000). A third form of learning called interactionism, where learning is creating meaning by appropriation, is described by Carlgren (1997).

A discussion of theories of learning relative to cognitive theory, psychodynamics and society is found in Illeris (2001). He interprets integrated learning as a combination of the influences from the surroundings that leads to psychological processes of learning in the individual and results in related integrated processes (ibid p. 15). Illeris' view of integrated learning connects to the constructivist view commonly used to describe student learning in Mathematics and Science. Carson concludes that constructivist theory obtained from Piaget's work favours a contextualist approach to Science teaching (Carson, 1998, p. 1013).

Different directions of constructivism explain individuals' integrated learning. Kant founded constructivism from his view of cognition as a holistic, non-reductionistic and constructive process (Araï, 2001) p. 14). Kant viewed representations of conceptions in the cognitive system as related to each other. According to Kant, these relationships are not random. Cognitive events conform to a holistic model. An exemplary short overview of the development of Kant's ideas by later researchers is in Hawkins (1994).

Different branches or learning tracks of constructivism have evolved in recent research. Gale counts six different branches of constructivism: social constructivism, radical constructivism, social constructionism, information-processing constructivism, cybernetic systems and socio-cultural approaches to mediated actions (foreword in Steffe & Gale, 1995). In his analysis of these different branches, Ernest (1995) sees a connection between these branches in their concept of construction: 'This is about the building up of structures from pre-existing pieces, possibly specially shaped for the task' (ibid. p. 461). Ernest suggests differences in research paradigm, ontology and epistemology between the different branches but a commonality in the salient idea that students construct knowledge. There are different views regarding environmental influences but a common view of learning progression.

According to Carson, liberal education is a way to bring about construction for a learner. Carson quotes Hirst in his expose of liberal education (Carson, 1998):

> '…equips the mind to enjoy a broad range of experiences that otherwise would remain inaccessible. Liberal education requires some proficiency in all of the major categories of intellectual culture. Expertise in a single field, whether science or literature, does not constitute a liberally educated mind.[…] …the multiple texture of understanding that

> one acquires that constitute the liberally educated mind. One of the key mechanisms in a liberal education could be the very fact that the learner is exposed to several distinct ways of knowing, several disciplined ways of thinking, which cannot be reconciled with each other. […] … freed from the tyranny of a single viewpoint.' (Carson, 1998, p.1006).

1.3 Integrated Science education

Integrated and subject-specific Science has been discussed both from the perspective of research in the natural sciences and as Science education. In this thesis it is only possible to give a brief glimpse of the ideas and work done in this field of research since 1966. As early as 1979 there were 130 different integrated curricula categorised according to Blum's definition in various parts of the world (Haggis & Adey, 1979). Integrated curricula were most commonly found in primary and junior secondary schools and less often in education at higher levels. Incidence of integrated curriculum has increased since then, according to later studies by Haggis.

Educational systems in different countries are organised differently. Discussions and questions regarding integrated Science necessarily vary from country to country. Some questions are however discussed at the international level. Some academic questions concerning integrated Science deal with epistemology and philosophy, e. g. (Frey, 1989; Schwab, 1964) Frey writes about work with integrating Science and Mathematics by UNESCO, this have become a long-lasting branch of discussion about how science should be taught. Schwab explores the special culture of Science compared to other school subjects. A writer that presents an early epistemological view of integration in Science, Mathematics and Social Studies is Ost. He discusses methods of integration such as interdisciplinary, unified, integrated, correlated, coordinated and comprehensive problem solving (Ost, 1975). Educational questions and problems of integrated Science education are discussed by others (Andersson, 1994a; Eijkelhof & Kortland, 1988; Penick, 2003). Andersson has studied the view of Swedish school students on integrated and subject-specific science in compulsory schools in the light of the national evaluation of 1992. Eijkelhof describes Dutch work using concepts in context. An early Swedish work that relates methods of integrating Science education in Swedish lower compulsory schools is presented by Svantesson (1971a, 1971b). An international view of the content of Science from a constructivist viewpoint and integration in Science is presented by Fensham et al. (Fensham, Gunstone, & White, 1994). The authors name three factors that make changes in Science education necessary: the variety of science content, the complexity of science content and science in action.

Schwab is one of the earliest writers on the nature of natural sciences. He discusses 'substantive structures of natural sciences' (Schwab, 1964) and reductive, 'organic', 'holistic' and rational scientific principles. These are, in his opinion, distinctly different ways of looking at Science and Science content. In his view reductive principles

> 'instruct the enquirer to treat his subject matter as something that takes on all its important properties from its own elements or parts and from the connections relating these parts to one another' (ibid p.46).

Schwab's definition of the holistic[1] view and rational principles is that the holistic view:

> 'explains its parts by reference to the describable but unexplained whole' (ibid p.47). 'Rational principles instruct the scientist to treat his subject matter as determined or explained by some system.' (ibid p.48)

All three structures (reductive, 'organic' or 'holistic' and rational scientific principles) are used in different parts of the sciences, according to Schwab. Schwab's writing indicates that different subjects in Science are distinct from each other. He mentions specifically Physics, Biology and Chemistry. According to Scriven this kind of distinction does not apply to the Social Sciences (Scriven, 1964). He claims that Social Sciences are constructed of History, Geography and Psychology. These subjects are strung together by means of logic, Mathematics and methodology. Economics, Anthropology, Sociology and Political Science supplement this field of study. Ethics brings all the subjects together in social action. Scriven (ibid.) maintains that no single subject in Social Sciences is independent of the others and can stand on its own. His view of Social Sciences is substantially different from Schwab's of natural science. One wonders when reading Schwab if it is possible to integrate Science subjects at all.

From a Swedish perspective, Andersson (1994a) discusses integration as a development project for schools "to connect different parts to a whole," from the individual's perspective. 'The teacher can facilitate integration, but at the end of the day it is the student who constructs the entirety.' (Andersson, 1994b). He discusses various kinds of simple integration: categorical (e.g. a bicycle, a car and a train form a new whole for the individual – vehicles), spatial (e.g. Nacka lies just north of Stockholm and Södertälje just south of Stockholm. A whole is created out of the parts Nacka, Stockholm and Södertälje with the help of a reference system), temporal (this is a question of fitting what separate events are to the individual into the flow of time) and causal (e.g footprints and the cat's paws, to begin with separate thins, are integrated by means of a causal relation – the cat walked in the snow and made footprints). He also treats more complex forms of integration, such as theory-integration, integration through causal chains or webs, integration through orientation systems and problem-focused integration (Andersson, 1994a).

A group in Australia has suggested that it may be erroneous to discuss subjects as a norm and integration as a change process and product (Venville, Wallace, Rennie, & Malone, 2002).

> 'We came to the conclusion that integration is a particular ideological stance which is at odds with the hegemonic disciplinary structure of schooling. A leap in understanding for us was the realisation that even the word "integration" implies that the "normal" state of a curriculum is a disciplinary format and that to integrate is a step beyond that status quo' (ibid, p. 46).

Venville et al. suggest that Science education should be treated as World Science. Integrated curriculum as a way of promoting change in curricula can be found in Bernstein's, Hirst's and Carson's work (see 1.2). Venville et al. create an opposing pair out of the terms disciplinary/integrated, a common viewpoint in Swedish Science education.

[1] Schwab equals organic and holistic.

1.4 Interdisciplinary or trans-disciplinary integration?

Integration of Science may occur within a subject or between subjects. This can be subdivided into integration in a single Science subject, within different Science-subjects and integration between Science-subjects and subjects outside the sciences. I present here a few practical examples of interdisciplinary and trans-disciplinary Science integration with comments.

Fogarty (1991), promotes integration both within subjects and between subjects. Her integration is both within subjects and between subjects, including integration with multiple intelligences. Fogarty describes a model of ten ways to integrate curricula. She states that integration may be within a single discipline, across several disciplines, within a group of learners or across a group of learners. Her model includes all states that are possible to work in and between subjects. Integration within a single discipline can be fragmented, connected or nested. Across several disciplines integration can be sequenced, shared, webbed, threaded or integrated. Within and across learners, integration can be immersed or networked. Fogarty's models of integrated curricula are both inter-disciplinary and trans-disciplinary. Fogarty develops her idea of ten models of integrated curriculum (Fogarty, 1995), where she combines Howard Gardners' seven intelligences with the ten different methods of integration.

An early example of two types of unified Science is found in Showalter (1973). The examples present two extremes on a scale of integration. Showalter's first example involved a trans-disciplinary structure and the second integrated between science subjects.

> 'Two examples of curricular structures are cited here to illustrate polar extremes. In one extreme, the unified science program has been planned on a K-12 basis and is titled Unified Science 1, Unified Science 2, ..., Unified Science 12 in sequential years. The program is composed of study units of four-to-six-week duration each. Each unit is organized around one of four theme types: a process, a concept, a persistent problem (e.g. pollution) or a natural phenomenon (e. g. Lake Eire). Specific subject matter has been chosen from many sciences, including the social sciences. Within each unit, the learner has a variety of learning modes available and makes some choices in what and how he learns.' [...] 'In the other extremes example, the curriculum structure was developed as a part-way of first step to achieving a "completely" unified science, In this structure, chemistry and physics are integrated into a single course in grades 11 and 12. The units of study are sequential and are very similar to chapters in conventional chemistry and physics courses. Specific subject matter is that of chemistry and physics. Learners have relatively few, if any, choices in what and how they learn.' (ibid p.26).

In the Netherlands, an interpretation of interdisciplinary Science as 'concepts in context' has been attempted in schools (Eijkelhof & Kortland, 1988). Research and development of compulsory school Science in Sweden by Andersson (1994b, 2001) also works with concepts in context; this perspective involves understanding natural sciences in the context of problems in the natural and social environment. Andersson adheres to a social-constructivist view of learning and developed several of these concepts (adapted to Swedish circumstances) in the later report.

Another international movement in Anglo-Saxon countries is the STS[2] movement. The movement's aims and ideology were developed by Cozzens (1990): 'Interdisciplinary means

[2] STS is an acronym for Science Technology and Society

integration of fragmented knowledge bases, and that is a significant part of the ideal of STS Thought'. Yager also worked with the STS movement. He writes (Yager, 1996):

> 'The STS approach is one that necessitates problem identification by individual students and individual classes. Such problem identification includes – by its very nature – a multidisciplinary view. There are few problems that are related only to science – certainly not to one science discipline' (ibid, p. 18).

STS teaching is integrated teaching with social studies as an ingredient. It entails trans-disciplinary subject integration of different disciplines. STS is also described by Aikenhead as a trans-disciplinary approach to learning science and technology in a social perspective (Aikenhead, 1994). He concludes "what matters is the school subject's integration with pupils' needs, interests, and lives outside of school" where Aikenhead quotes Erlandsson (Aikenhead, 2003). STS according to Aikenhead contains the student's view in high degree and it is the student's choice of interest and every day life that is in focus.

Those among Science teachers who criticise the STS approach suggest that Science education becomes too superficial and uninteresting when it is connected to Social Science to achieve scientific literacy. This argument is used by Shamos in his discussion of the STS-movement in the U.S.A. (Shamos, 1995). Fearing poorer student results, some Science teachers resist changing traditional Science teaching in favour of an approach they don't believe will result in approved student knowledge. Although the STS movement has not flourished in Sweden, there is a similar debate about the dangers of integrating Science subjects with non-Science subjects among science teachers.

1.5 What is meant by subject-specific science?

Science teaching that is not integrated is usually named as traditional (like Hirst, mentioned in section 1.1) or textbook Science (Yager in section 3.2). The advantages and disadvantages of this organisation as well as the methods used when teaching subject-specific Science itself are seldom debated. A review of Science textbooks provides some insights into this approach to teaching. The nature of subject-specific Science as opposed to integrated Science is poorly understood in Swedish school debates, since debates usually focus on other issues. However, one example of dealing with the issue is found in Marklund (1983). He places formal (theoretical) education in opposition to practical training, subject view in opposition to student-centred and orientation in opposition to advanced. All these pairs of opposites are debated in Swedish curricular discussions.

Bernstein (in the work referred to in section 1.1) contrasts integrated with collected curriculum. Bernstein's collected curriculum seems to be a form of subject-specific curriculum. Hirst (in the work referred to in section 1.1) contrasts integrated with traditional teaching. Hirst's traditional curriculum seems to bear resemblance with a subject-specific curriculum, a common form of Swedish Science education.

In this thesis, subject-specific Science means the separate subjects of Biology, Chemistry and Physics. The descriptions of Bernstein and Hirst are relevant in this context. Subject-specific Science is the traditional way of teaching Science in Swedish lower secondary schools. Hirst's traditional curriculum is presumed when referring to subject-specific teaching.

Bernstein writes about subjects with strong boundaries and in Sweden this is applicable for subject-specific Biology, Chemistry and Physics.

Another view associated with Science education is described in Roberts (1988). He discusses curriculum emphasis from four different perspectives (Science, learner, teacher and society). In his analysis, different viewpoints appear in different categories. Roberts points out the 'difference between educating a Science teacher and winning an ideological convert' (ibid p.50). According to him, Science education is often dogmatic and doctrinaire even though the content is only one professor's views. This might be confused with a subject-specific view since a professor often has a subject to protect and teach. The dogmatic and doctrinaire view of the teacher might be confused with the content of the subject by the learner. If the learner does not succeed in distinguishing between the teacher's subjective view and the organisational, the organisational form may be rejected for subjective rather than logical reasons.

Wennberg deals with the way different actors affect schools. He uses four labels such as Essentialism, Progressivism, Reconstructivism and Scientism to denote different actors in school. Two of the labels are applicable in the context of integrated and subject-specific Science for this study. According to Wennberg Essentialist people have a traditional view of school; for them, subjects are of primary importance in the school. He studied the subject Earth Science in Sweden and found teachers that at one time may be called Progressives become Essentialists at another time, when their teaching becomes traditional and subject centred (Wennberg, 1995). In an earlier work he wrote about the forces behind two school reforms in Sweden (Wennberg, 1990). A thorough description of two views of Swedish school politics appears in this work. Here we find Progressives who want to work in projects and themes and Essentialists or Systematist[3] who represent traditional subject teaching. The Progressives are in this case proponents of integration and Systematists are proponents of a subject-specific curriculum.

Subject-specific science contains some difficulties, according to Hirst and Roberts, as referred to above. Some of the difficulties spring from struggles between groups of people with different ideologies of what to work with and how to work in schools as described by Wennberg. In this thesis the opposing sides are not illustrated. It is only established that teachers can organise science education in Sweden differently and teachers statements on how they work in science are used and analysed as data and not as ideological claims.

1.6 Integrated Science in the Swedish school system

The question of how to organise Science education has been a matter of debate in Sweden. During the 1980's discussions dealt with how to grade students in Science. In 1982 the school law was altered so that students received a single grade for all Science subjects. Teachers from an academic tradition opposed this and demanded subject-specific grades. The Agency of Education appointed a commission to look into this issue. The commission concluded that schools should be allowed to achieve curriculum goals any way they want but since goals are formulated in terms of Science, only one grade may be given. This led to a heated debate that ended with a decision to allow schools to choose between two grading systems: either to grade students in Biology, Chemistry and Physics or to give them a single grade in Science (Andersson, 1994a; Riis et al., 1988).

[3] Wennberg calls a group of persons having the essentialist view also as systematists

A second debate started with the reform of 1994 with a discussion of whether or not Science should be integrated in all compulsory schools. Englund and Östman feared that the new curriculum with separate subjects in Science would rule out integration and the democratic work accomplished in the earlier school system, in which Science and Social Science were integrated to an increased extent (Englund & Östman, 1995). The question I raise at this statement is if democracy equals integration or if integration is something that have a meaning of it's own beside democracy? It is possible that integration only can be done in a democratic school system, but is integration the only way of work democratic in school?

At present, the curriculum for Swedish compulsory schools grants schools autonomy in planning Science teaching, organised as integrated or subject-specific teaching (Skolverket, 2001). Sweden has a long tradition of Science teaching in the compulsory school system. Science and Social Science are usually integrated during the first school years and these subjects are taught by the same teacher or a team of teachers (Henriksson, Gisselberg, Karp, Lyxell, & Wedman, 1987). In the seventh grade children usually meet Science in separate subjects (Biology, Chemistry and Physics). Divided and specialised, the contents of these subjects are a miniature of the academic disciplines.

1.6.1 Studies of the occurrence of Science integration in Sweden

In the SIMSS[4] study of 1982, teachers answered a question about integrated Science teaching in Sweden. About 40 percent of teachers in lower secondary school answered that they sometimes or seldom taught Science in an integrated way. Sixty percent answered that they never taught integrated Science. In a subsequent open question, teachers could freely express their opinions on different things. On the basis of those answers, the researchers concluded that Science teachers are unwilling to teach integrated Science (Riis et al., 1988).

In the Swedish National Evaluation of 1992, school teachers were asked what kind of grade they gave students. About 20 percent gave Science grades and 80 percent gave separate grades in Biology, Chemistry and Physics. The National Evaluation assesses different concepts in Science divided into Biology, Chemistry and Physics. Researchers found that students with subject-specific grades did not score significantly higher than students with integrated grades in the three Science subjects. Comparing other school subjects (Mathematics and foreign languages), no significant differences could be determined between students who received integrated Science education and those who were taught subject-specifically. It was however noted that students with subject-specific grades more often applied for a Science program in upper secondary school than students with integrated grades. Students with integrated grades were on the other hand more confident and satisfied with their lessons and felt that they had learnt more (Andersson, 1994a).

A five year national project in Sweden with no set timetable has generated several reports on how schools participating in this project implement this. One of these studies were done by Alm, (2003) who studied schedules for 326 schools from grades 1 to 9 in the compulsory school system. He classifies timetables in five levels, ranging from type 1 (with only alternative names of school work) to type 5 (where most lessons have subject names). In schools with 'type 3-tables' about half of the schools taught using themes. This type of

[4] Second international mathematics and science study

schedule is most common in grades 1-6. Themes or thematic studies are found in about one fifth of the schedules studied and are statistically significantly more common in grades 1-3 (ibid, p 43). There are as many themes in the schedules of grades 1-3 as there are in grades 4-9 together.

1.6.2 Integrated Science in the previous Swedish curriculum

Riis has written about integration in the Swedish curriculum through the reforms of 1948, 1955, 1962, 1969 and 1980 (Riis, 1985). She discusses the forces that drive subject division and identifies factors such as social division into sectors and atomisation of knowledge. She discusses four perspectives of integration: ideology, theory, personal integration and integration into everyday life. Concerning the factor ideology, Riis wrote that religion played a major role in this area in early curricula but was later supplanted by democratic ideology in the 1960’s. Regarding theory, she pointed to scientific objectivity as a motive force together with economics. The personal integration comes in lgr 80 as well as the thought about integration into every day life. Who’s every day life that is intended is not specified, as far as I can find in the context of the curriculum, but preferably it would be the students every day life that is intended. When reading the text about the details needed in planning the themes according to the curriculum lgr 80 it is hard to imaging that the student’s have the possibility to make personally choices.

One part of the curriculum from 1980 (lgr 80) concerned the school day and time spent by students in school (Skolöverstyrelsen, 1980, p. 20). Teachers and students were expected to plan the school day together (ibid, p.21). The concept of theme work was used in this context, not as applied in particular to teaching organisation but in the context of other school activities. This was a particular form of integration for students.

Another form of integration involved individually chosen themes within a subject. Work material and work organisation included visits, textbooks newspapers and experiments. The time to work on a theme was taken from a subject’s total time (ibid, p. 29). Thematic studies of this sort were compulsory in grades 7-9 and on average 4 student hours per week during the three years were to be spent with themes in these grades. Theme planning was strictly regulated in the curriculum and it was planned in great detail by the work unit, so the headmaster would be able to create schedules as needed.

> ‘The content of a theme shall be in the frame of the main objectives in a subject or subjects. […] If the students and teachers wish, the work can be multidisciplinary. […] Different themes should be treated during a school year.’ (ibid, p.35-36, my own translation).

What a theme consisted of and how students worked with themes was up to the teachers themselves.

1.6.3 Integrated Science in the current Swedish curriculum

A new national curriculum for the compulsory school was established by the Ministry of Education in 1994. The curriculum describes the responsibilities of the schools and various authorities. There is a general description of what schools must accomplish. The curriculum points out that a student must learn to be able to manage new and changing situations. Students must learn problem solving and be able to work independently (Utbildningsdepartementet, 1994a, 1994b, p.7).

This view of knowledge is based both on subject-specific and integrated thinking:

> 'Knowledge is a complex concept which can be expressed in a variety of forms – as facts, understanding, abilities and accumulated experience – all of which presuppose and interact with each other. The work of the school must therefore focus on providing scope for the expression of these different forms of knowledge as well as creating a learning process where they balance and interact with each other to form a meaningful whole for the individual pupil. The school should promote the harmonious development of pupils. This is to be achieved by means of a varied and balanced combination of content and working methods. Common experiences and the social and cultural world that make up the school provide scope as well as the preconditions for learning and development where different forms of knowledge make up the coherent whole' (ibid, p. 6-7)

This text begins by explaining the content of knowledge: fact, understanding, abilities and familiarity. The first of these concepts is connected to traditional ways of looking at education and the last two concepts lean more towards knowledge through experiencing (Molander, 1996). The last part of this text quote contains 'a whole' that can be seen as integration. Teachers are expected to integrate knowledge. 'Teachers should endeavour to balance and integrate knowledge in its various forms' (ibid, p. 9). The section that deals with the head of the school expands the duties of the school leader to include facilitation of integration at the school level. This section also gives directions as to what themes are advisable to study in schools.

> '…teaching in different subject areas is co-ordinated so that the pupils are provided with the opportunity of broadening their overall understanding of wider fields of knowledge. […] interdisciplinary areas of knowledge are integrated in the teaching of different subjects. Such areas cover, for example, the environment, traffic, equality, consumer issues, sex and human relationships as well as the risks posed by tobacco, alcohol, and other drugs.' (ibid, p. 18)

The National Agency of Education has written commentaries to the curriculum, syllabi and grade criteria. The content and organisation are discussed by stating (Skolverket, 1996):

> 'The argument to organise and choose content in one way or another must be based on professional considerations and local conditions. […] Even if the goals and the quantities of the students' knowledge to be assessed is written as subjects it does not necessarily mean that the education should be organised subject-wise or that the content should be structured in that way. On the contrary there's a lot to be said for considering other forms of organisation if schoolwork is to be meaningful for the students (ibid, p. 20, my own translation).

This text promotes integration of the content in school. Even though the curriculum is divided into subjects, students should have the possibility of creating, organising and integrating knowledge: 'The schools' assignment of knowledge involves on the one hand transmitting earlier generations' knowledge and on the other creating conditions for the students to organise and integrate in a meaningful and useful way.' (ibid, p. 21) Nevertheless, organisation by subject is not abandoned: 'Goals on the reproductive side of knowledge assignments are in the present curriculum organised subject-wise and express the aim that different aspects and qualities of the students' knowledge shall develop.' (ibid, p. 21).

Science education received one syllabus in Science and three in each subject of Biology, Chemistry, and Physics. They all follow the same general structure. First there is a common text, followed by a description of the aim of the subject and its role in education. After this general goals for the subject are presented as well as the structure of the subject and goals that students should achieve in grades five and nine. The structure of the subjects follows a common structure with three themes: knowledge of nature and man, scientific activity, and use of knowledge. The Chemistry and Physics syllabi follow this pattern. Biology has four dimensions: the ecosystem, biological diversity, the cell and living processes and humans. Goals in Biology are similar to those in the other Science subjects with the three themes of knowledge of nature and Man, scientific activity and use of knowledge. The structure of the Science subjects differs from the Social Sciences, which do not show the same level of integration.

Summing up the current curriculum (Lpo94) and the previous curriculum (lgr80), there are some differences between integrated and subject-specific Science to highlight. There are although some difficulties in comparing the two curricula, since they have different structure and different level of details in the prescription of what the schools are supposed to do. There was more emphasis on thematic work in lgr80 than it is in Lpo94. Lgr80 prescribes the amount of hours that should be used for thematic work, Lpo94 is giving freedom to the schools work organisation that lgr80 does not. In Lpo94 the spirit of how the schools are supposed to work is written about, but the content and organisation is highly left to the schools and the curriculum is general. Therefore it is difficult in an overview study like this thesis to get theoretical insight of how the intended integration in schools is supposed to look like according to Lpo94, without commentaries and supplementing materials. How integration actually is carried out in schools at practical level is even harder to get to know, since schools have freedom in the way they can work in schools according to Lpo94 it is also possible that they use this freedom and that they work in quite different ways.

2. Previous research

2.1 Studies of teaching styles and student results

Bennet compared the use of integrated and subject-specific Science with students' results in grades three and four in Lancashire and Cumbria (Bennett, 1976). He compared progressive and traditional teaching styles and described twelve different teaching styles. The progressive teaching style had as its first criteria integrated subject matter and the traditional teaching style had as its first criteria separate subject matter. A cluster analysis of 468 fourth grade teachers resulted in twelve types of teacher styles. Three types included teachers that preferred integrated Science and eight types consisted of teachers who preferred subject-specific teaching. One type was mixed. With further analysis, these twelve types collapsed into three teaching styles: formal, informal and mixed. Integrated and subject-specific teaching could not be distinguished from formal and informal teaching styles.

When evaluating students' results in Reading, Mathematics and English, Bennett made a comparison of different gains relative to the three teaching styles. Students in formal and mixed classes gained better than predicted in Reading and students in informal classes gained less than predicted. Students in formal classes gained better than predicted in Mathematics while mixed and informal classes gained less than predicted. Students in formal classes gained better than predicted in English while students in mixed classes gained as predicted and students in informal classes gained less than predicted.

Bennett described the kind of students who benefited or experienced disadvantages from different teaching styles. Students with high and low achievement levels benefited from formal teaching. Work-related pupil interaction was higher in informal teaching for both groups. Teacher interaction was higher in formal teaching for all level of achievers.

Bennetts' data was re-analysed by Aitkin et al. (Aitkin, Anderson, & Hinde, 1981). They found 'three latent classes and no single continuum of teaching style. The formal-informal "dimension" does not adequately describe the "mixed" teachers, who are not intermediate between the other two styles on the disciplinary and testing items.' (ibid, p. 428). Aitkin's et al re-analysis of the data produced no evidence for the assertion of a correlation between teaching style and students' test scores. Aitkin et al. found that students in formal classes gained as expected in Reading while students in mixed classes gained less than expected and students in informal classes gained better than expected. Students in mixed and formal classes had the same results in Mathematics as in Bennett's study but students in informal classes gained better than expected in contradiction to Bennet's results. Students in formal classes gained in the same way in both Bennet's and Aitkin's studies in English but differences appeared for students in mixed and informal classes. These results, although statistically insignificant, were nevertheless different from Bennet's. Aitkin writes that 'the formal classrooms do best in English, the informal classrooms do best in Reading, formal and informal classes are very similar in Mathematics and the mixed classrooms do worst in all tests' (ibid p. 438). He concludes that 'individual variations in teacher ability are much more important for pupil achievement than teaching style differences' (ibid p. 439).

The Swedish national evaluation of compulsory school in 2003 analysed teacher priorities, classroom situations and conditions in the light of teachers' and students' attitudes (Skolverket, 2004a). A second analysis of the data collection was done by the National Agency of Education (Skolverket, 2006a). This report concludes that teachers' educational backgrounds (both in education and the subject taught) together with teacher enthusiasm are important factors influencing student results. This report did not analyse teaching styles. Student results according to teaching style has been analysed in three core subjects: Swedish, Mathematics and English. The report discusses different cultures in the different subjects as a probable explanation for differences between subjects.

In the five-year project with no set timetable, there is a focus on the proportion of schools who work with integrated subjects (SOU 2004:35, 2004, p.80) A growing number of schools participating in this project reported that they intend to start or have started integrated teaching. Students at schools participating in this project have shown better test results than students in other schools (SOU 2005:101, 2005, p. 146). A possible explanation for this is that more freedom to apportion time and resources leads to better priorities and better student results.

Davies (1972) presents another approach to organising teaching and discusses effectiveness in teaching styles. In his description of three teachers' basics styles, integration is found to arise from student needs as well as organisational philosophy. Integration was only one part of the teaching style studied and Davies did not focus on this issue.

2.2 One conceptual framework for curriculum study

The conceptual framework of TIMSS is used in this work as a frame for the qualitative study. Other frameworks for curriculum studies could have been chosen, but this is a simple and illustrative theoretical framework with not too many levels. The conceptual framework for the TIMSS study consists of three levels. All three levels influence each other, but the dynamics are from the intended to the implemented to the attained and not the other way around. There are more things that influence the students' attainment of the school's curriculum than the influence of the environment on the student. An overview picture of the framework is found in figure 1. A short description of the ideas of the conceptual framework follows.

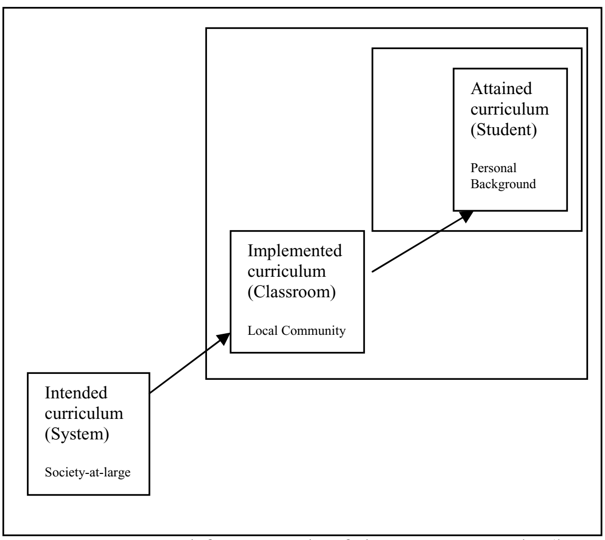

Figure 1. Conceptual framework of the TIMSS study (based on Robitaille et al., 1993)

The variables influencing education are seen as situated in a series of embedded contexts starting from the most global and moving to the most personal. The narrow contexts are influenced by the broader ones in which they are embedded, but they are not only subsets of the broader contexts (Robitaille et al., 1993). Educational environments exist in a total environment that is larger than the world of education.

> 'The boundaries between the content, the institutional arrangements, and the societal context are not always distinct. Nor is it important that they be clearly delineated. The important point is that the variables of three different kinds of content need to be considered in the light of three different levels of institutional arrangements, within three different societal contexts. Together, the content and institutional arrangements of the intended, implemented, and attained curricula, together with features of the society-at-large, the local community, and the educational environment.' (ibid p.30)

The intended curriculum is Science defined at the national or school level. The intended curriculum is embedded in textbooks, curriculum guides, examinations, policies, regulations and other official documents designed to direct the educational system. It can be described in terms of concepts, processes and attitudes.

At the community level the implemented curriculum is Science content presented by teachers to students. It can also be described in terms of concepts, processes and attitudes. The focus of the implemented curriculum is the school or classroom. This includes teaching practices, aspects of classroom management, use of resources, teacher attitudes and backgrounds.

The attained curriculum is the outcome that consists of schooling, concepts, processes and attitudes towards Science that a student acquires in the school. What students learn is influenced by what was intended and the quality and types of opportunities made available to them (both the intended and the implemented curriculum). It also depends on the institutional arrangements such as amount of homework, efforts by the student and student classroom behaviour patterns. The students' personal background influences the outcome of his/her studies.

2.3 Student results in OECD's PISA

Harlen uses the PISA-study's definition of scientific literacy (Harlen, 2001). This definition contains four aspects 1) Science processes 2) Science concepts 3) Areas of application 4) Situations within which assessment units are presented. There are five Science processes selected for inclusion in PISA: 1) Recognising scientifically investigable questions 2) Identifying evidence needed in a scientific investigation 3) Drawing or evaluating conclusions 4) Communicating valid conclusions 5) Demonstrating understanding of science concepts. Harlen discusses the rationale of the PISA-study. PISA aimed at not merely defining each domain in terms of mastery of a school curriculum but also testing children on important knowledge and skills needed in adult life. PISA's definition of scientific literacy is fully described in Harlen (2001). The scientific literacy definition in turn was dependent on work done by Bybee (1997). The PISA study writes:

> '*The OECD/PISA represents a new commitment by the governments of OECD countries to monitor the outcomes of education systems in terms of student achievement, within a common framework that is internationally agreed. A primary reason to conduct this assessment it to provide empirically grounded information that will inform policy decisions. OECD/PISA has set up a different approach than for example the TIMSS study. It is governments that have taken the initiative and whose policy interests the survey will be designed to serve.*'(OECD, 1999)

Knowledge and skills tested in PISA are called life-skills and are defined by PISA as '*The knowledge, skills, competencies and other attributes embodied in individuals that are relevant to personal, social and economic well-being.'* (OECD, 1999) The PISA project devoted a good deal of effort to assessing active knowledge of reading and learning strategies, the ability to find answers in complex texts and the ability to judge and estimate different outcomes on the basis of given facts.

2.3.1 Similarities and differences between OECD's PISA and IEA's TIMSS

Differences between the PISA-study and the TIMSS[5]-study can be found in Fensham and Harlen (1999). The main difference between the intentions of PISA and TIMSS is that the PISA study is not founded on different countries' curricula but rather 'learning outcomes for science that had not previously been emphasized and as a test it was unlike the types of testing that were familiar in the countries' school systems.' (Fensham, 2004). A thorough analysis of the differences between PISA and TIMSS can be found in Olsen (2005). He analyses differences and similarities between these two large-scale assessments in terms of test domain, organisation, participation, population, samples, design and instruments.

Curriculum is central to the TIMSS study. It distinguishes between intentions and outcomes to discover discrepancies between the two. In PISA life skills are prioritised over school-defined skills. This is not surprising since OECD initiated the project. One of the main competitive elements in a country is its general knowledge level (Gustavsson, 2000).

An indication of differences in results between PISA and TIMSS may be found in that the PISA test discovered that girls score as well as boys in Science at international level (Fensham, 2005). The PISA project's language literacy component has been extensively discussed. Since items in PISA need good reading skills and girls score higher in reading than boys, girls' better scores in Science may be due to their better skills in reading.

In Sweden in the TIMSS study boys scored higher in Science than the girls (Skolverket, 2004b). One possible explanation of this difference between girls and boys in the TIMSS study is that girls in Sweden favour the open question format; this has been established in TIMSS' question format studies in Swedish TIMSS (Eriksson, 2005).

3. The present study

3.1 A Science education question

One of the most discussed questions in Science education during the 1980s and 1990s was what results Science education should lead to. Is the goal preparation for secondary school and academia or universal scientific literacy? This has been thoroughly discussed in the Science education society of Great Britain (Jenkins, 1999), Australia (Fensham, 2000; Fensham & Harlen, 1999), and Canada (Aikenhead, 1996). What does good Science education lead to and look like?

School debate in Sweden has dealt with the efficient use of school time, (Westlund, 1998) and integration and individualisation (SOU 2004:35, 2004). Sweden has had two curriculum reforms (1994 and 2000). Teachers have experienced major cutbacks in work time while responsibility for schools shifted in 1989 from the state to the municipality. All these factors have influenced discussions of school Science although none have dealt with the content of Science education. What is seen in international assessments like TIMSS and PISA is that low achievers in Science in Sweden are loosing in the score results compared to other countries (as is found from PISA 2003) (Karlsson & Åström, 2005). It is also found from TIMSS 2003

[5] Third international mathematics and science study, this became Trends in international mathematics and science study when the fourth study was launched.

that high achieving students are loosing score results in Science compared to other countries (Karlsson, Kjaernsli, Lie, & Åström, 2006).

In this thesis I will explore a school-level description of integrated and subject-specific Science education, since one of the Swedish debates in the early 1980s have dealt with integrated or subject-specific grading in Science education. There are mainly two differing groups in Science education, one that is pro integration and one that is pro subject-specific Science. Is it possible to find some explanation of successes in Science learning in a systems level study approach of student's assessment results?

In section 1 my research query started with the questions of why and how, and then I gave some short examples of what content integrated Science education could possibly have. This thesis is concentrated on why and how integration is carried out, and less of what is integrated. The research in the two studies in this thesis is to find differences and similarities between integrated and subject-specific teaching organisations. The differences and similarities are searched for both in students' results in scientific literacy and in the description of teacher practices working either integrated or subject-specific.

Even though the main issue of this thesis is not to find out what content that is integrated, what content that is taught about and learned is of course important both in integrated and subject-specific teaching organisations. This thesis touches the content of scientific literacy of the PISA assessment. The different organisations of Science classrooms have the same rationale for both students with integrated and subject-specific Science. A discussion of what kind of content that is built by integrated and subject-specific Science education is of subordinate order since the PISA assessment tests the same content. All teachers are working with the same curriculum and therefore would have the same goals to accomplish independently whether if they work integrated or subject-specifically. There are yet to examine if PISA assesses the whole of the Swedish science curriculum, and not only a part of it.

- This thesis attempts to determine differences in the total scores in Science literacy in students' results between integrated as opposed to subject-specific Science teaching in the compulsory school system.
- This thesis describes similarities and differences between integrated Science education and subject-specific Science education and gives some examples of schools that use the different Science education organisations.
- This thesis tries to give an explanation of the results of the two studies.

This will give a broader spectrum of one of the questions in Science education, whether or not integrated Science as well as subject-specific Science gives good students' results in written assessments. The thesis is based on two studies.

As described in above sections the integration versus subject-specific teaching organisation is not a well defined and singular phenomenon. In this thesis the teacher's views of how they work with and how they interpret Science education is taken as data and analysed according to established statistical and qualitative methods. The expression of the teacher's statements done by the researcher is to interpret thematic organisation as integration and the use of different subjects Biology, Chemistry and Physics as subject-specific organisation. This follows the interpretation done by Andersson in his study of 1992.

3.1.1 Study 1

One quantitative study uses data from OECD's PISA 2003 study. Data on a variable of school views regarding integrated and subject specific Science was collected supplementary to the main study in Sweden. This was done by means of a survey that was sent to schools in autumn, 2003, after the ordinary cycle of PISA 2003 in Sweden was completed. The survey that was sent to the schools is found in appendix 1 in this thesis. This survey is referred to as the survey of autumn, 2003 in this thesis. The survey of autumn, 2003 focused on whether schools work integrated or subject-specifically. Either the headmaster or teachers at the school replied to the survey. The survey question was formulated to clarify if schools work with themes. Answers were categorised into three levels and used as a variable for statistical data analysis of the relation between different teaching forms in Science education and student results in the Science part of PISA 2003. One difficulty in asking about integrated as opposed to subject-specific teaching is that the term "integrated Science" is not well defined and may mean different things to different people. Integrated science can be thematic studies or project studies with a mix of work organisation and content. Integrated science can be a single subject in Swedish schools called "Nature oriented" or general Science (NO); this single subject contains Biology, Chemistry and Physics in an integrated way. Integrated Science can also refer to those weeks when schools give themselves over to interdisciplinary work with large themes such as drug abuse. During these periods all school subjects are involved. In this study's empirical section, integrated Science and the Swedish subject NO are used interchangeably. Subject-specific Science in Sweden consists of Biology, Chemistry and Physics and each of these three subjects are allotted their own school time. Subject-specific Science in this thesis refers to Biology, Chemistry and Physics as separate subjects. Different aspects of integrated and subject-specific Science education are dealt with in the theoretical section and the second article in this study.

3.1.2 Study 2

The second study contains interviews of a selected group of teachers and questions from a pilot study done in 2005 to test items used in PISA 2006. This study aims at gaining a description of how teachers work with Science education, what rationales and interests they express when planning Science education and what teachers emphasise in a description of their work. The focus was on teachers' ideas and descriptions of the integrated or subject-specific Science they work with. Analysis of the interviews was performed according to theories regarding integrated and subject-specific teaching described in section 1.1. Analysis was also performed in comparing and finding patterns of similarities and differences between teachers in the selected schools. The interviews and classroom observations were conducted in autumn, 2004. School questionnaires and student questionnaires were carried out by schools late in the ninth (last) year of compulsory schooling for students, spring 2005. The results of the school questionnaire were compared to the interviews. The results from the student questionnaires on questions regarding work organisation in Science were analysed statistically and compared to the teachers' stories.

3.2 Perspective of this study in relation to earlier studies

This thesis began with a review of earlier work on integrated and subject-specific teaching, or ideology in education. Bernstein's theoretical work on integrated and collected curriculum is an interesting starting point (Bernstein, 1975). Hirst's ideas about formal and learning to learn curriculum (Hirst & Peters, 1970) are similar to Bernstein's ideas regarding collected and integrated curriculum. Hirst's formal curriculum corresponds to Bernstein's collected curriculum and Hirst's learning to learn curriculum corresponds to Bernstein's integrated curriculum. Liberal education as described by Carson (1998) is also similar to the integrated curriculum idea. In the experimental part of this thesis, integrated and subject-specific Science education is presented as opposites. In Sweden, integrated science goes under the name NO and in this thesis NO and integrated Science are used as interchangeable terms. Subject-specific Science consists of Biology, Chemistry and Physics and these terms are also used interchangeably, se also section 1.5.

Bennet tested his ideas on integrated and traditional teaching in his study of progressive and traditional teaching methods for different student categories and student results in English, Reading and Mathematics (Bennett, 1976). This study does not provide a clear and unambiguous picture of teaching styles or classroom work in English schools. This is similar to what others have written about integrated and subject-specific curricula in Sweden (Riis, 1985) and Australia (Venville, Wallace, Rennie, & Malone, 2002). In the light of Bernstein's work it is not unexpected that twelve teaching styles collapse to only three. Bennett finds however three different teaching styles as opposed to the two discussed by Bernstein.

Although tests of student results on the basis of teaching style in Science are needed, not much work has been done in the area. Marklund discusses the lack of studies in this area (Marklund, 1983). Andersson conducted a Swedish study of student results in Science and student attitudes towards Science in connection with the Swedish national evaluation in 1992 (Andersson, 1994a). His study showed that student results by different teaching organisations (integrated or subject-specific).

Jenkins studied student results in different curricula in England (Jenkins, 1993). He found differences in student results depending on whether the students worked with an orientation curriculum or a separate subject curriculum in lower secondary school Science. That study was different than others because the curricula compared were different: the orientation curriculum did not include all Science subjects while the separate subject curriculum did. The amount of time used in different curricula also differed between the two groups compared.

A third study (or group of studies) by Yager analysed student results for different forms of integrated teaching over a long period of years. Examples of integrated methods studied include textbook-free teaching and its effect on critical thinking (Yager, 1968), STS teaching compared to textbook teaching (Yager, 1996) and the effect of STS teaching on critical thinking (Yager, Mackinnu, & Yager, 2005). According to Yager, integrated Science produces better student results than traditional Science.

This present study is therefore not pioneer work in the area of integrated and subject-specific Science in relation to students' results. What is new is the use of the curriculum from the Swedish school system together with PISA 2003.This curriculum is different from the one (Lgr 80) studied by Andersson in 1992. Besides PISA 2003 uses another rationale of Science knowledge compared to Andersson's. The rationale of PISA 2003 is scientific literacy and 'life-skills' in Science. Andersson's rationale was connected to the rationale of the Swedish Science curriculum.

4. Method

This section deals with the research methods used in the two studies in this thesis. More details about the how the particular methods are used in the studies are found in each article. Since I have used both quantitative and qualitative methods both methods are discussed in this section. A discussion of the quantitative study comes first, and secondly a discussion of the qualitative study follows. Some ethical aspects of the research are also mentioned.

4.1 Quantitative study

In the first study I begin by examining results from a large-scale international assessment of approximately 2000 students. The population of this study consists of ninth grade fifteen year-old students who took the science part of the PISA 2003 assessment in Sweden. Results are statistically analysed using hierarchical linear modelling (Tabachnick & Fidell, 2007), with variables of country of birth, home language, preschool attendance and an index of economic, social and cultural factors studied as covariates of the teaching organisation of the schools. The variables are chosen to allow comparisons with PISA 2003, Mathematics (OECD, 2004), but also because those variables commonly have the largest impact on student's results. The assessment content of Mathematics and Science has different results in PISA but since the chosen independent variables explain much of the variation, it is of interest to look at the extent of the variation explained.

4.1.1 Validity

There are some considerations concerning validity when using assessment instruments like PISA. According to Linn and Gronlund the following five things are considerations that need to be taken in account when reasoning about validity; Validity refers to the appropriateness of the interpretation of the results of an assessment procedure for a given group of individuals. Validity is a matter of degree. Validity is always specific to some particular use or interpretation. Validity is a unitary concept. Validity involves an overall evaluative judgement (Linn & Gronlund, 2000, p. 75-76). Linn and Gronlund also write about four considerations of validity in assessment that are all related, but can be taken into consideration to different degrees depending on what kind of assessment there is at stake. The four considerations are; content, construct, assessment-criterion relationship and consequences for teachers and students.

The quantitative design of the first study allows us to find the frequency of the schools and students having integrated and subject-specific teaching. It also gives us the opportunity to correlate students' results to the different organisation of teaching and study if there are differences between the students' results that would be related to the organisation of teaching. The methods used are statistical methods, and hypothesis testing with statistical interference. It is used to test hypothesis, in this case to find if there are differences between two ways of organising Science education. The statistics address the question of if there are differences between different groups, and if this difference is statistically significant. The statistical strength of the test is a measurement of the ability of the statistical test to examine a difference between the null-hypothesis and the hypothesis that there are differences between the groups or categories. The model used is an abstraction to describe the data. The metric level of the variables that are measured is a crucial issue for the kind of model that can be used to test the hypothesis (Henriksson, 1999).

In this study statistics are used to test the hypothesis that there is a difference between groups of students that are taught using integrated Science education and groups of students that are taught subject-specifically in Biology, Chemistry and Physics. A first question of the validity of the assessment instrument would lead to a too long discussion for this thesis, and will not be developed in whole at present, but a lively debate about the advantages and disadvantages of an assessment tool like PISA is current in the research community. One advantage that can be observed is the reports written about the results that gives us more knowledge about the school systems in different countries (OECD, 2001, 2004). Interesting results of gender differences have been found (Fensham, 2005). Students' results in different content in Science are also found (Olsen, 2005). The disadvantages of large-scale assessments are discussed, mainly at a systems level and concerns about the assessment effects. Sjöberg (2002, 2005a, 2005b) is concerned about the top-down view. Prais wonder about the aims of PISA (Prais, 2003). Criticism related to students' ability to learn is noted by Goldstein (2004).

Another, second question concerning the validity of the statistical method used is maybe easier to discuss briefly. The sampling of the PISA assessment mainly determines what kind of analysis method is useful. Since the sample is nested at two levels and designed with students at one level and schools at the other (OECD, 2005) a hierarchical linear model is an appropriate way of analysing the differences between the means of the sample (Tabachnick & Fidell, 2007). The hierarchical linear model is able to separate the calculation of variance of the individual level from the variance of school level. This is necessary since one presumption is that students in a class with the same teacher are not independent in the statistic analysis.

When summarising the different parts of the validity discussion the process used with the assessment instrument and the statistical methods are satisfactory. One remaining issue when discussing validity in the quantitative study is the variable of teaching organisation. Is it an appropriate variable to use? Since the findings of study 1 is that there is no difference found between the different groups student results more studies about what is meant with integrated and subject-specific science is needed. The debate about different teaching organisation is maybe not dependent on the students' results on written tests.

4.1.2 Reliability

Reliability is concerned with the consistency of the measurements. Is it possible to reproduce the results with the same data, and is it possible to reproduce data and get the same results?

The measurement procedure of PISA is well documented (OECD, 2002, 2005). Reliability of the assessment instrument is guarantied by the assessment procedure. The students' results are assessed by comparative judges in multiple rounds. Inter-judgement reliability is measured and reported. The concerns about PISA are that the content of the items measure what was intended. Bonnet (2002) has concerns of reliability of some of the test items; that not the same amount of skills are reported as it was intended to measure, which raises the question of making an independent comparison.

The variable of school organisation that is collected in the survey of autumn 2003 is a more empirical untested factor of the study and therefore more uncertain than the others. This is since there are difficulties in knowing what the label of the different types of organisation really describe. The agreement between the schools' answers to the survey in autumn 2003 and student grades in Science is not completely coherent, as is discussed in section 5.1.1. This may mainly be associated to the socially negotiated facts in the schools of the integrated and subject-specialised organisation of Science education. Socially negotiated facts can have different meaning and content to different users and at different times. A discussion of socially negotiated facts is found in (Searle, 1995).

4.1.3 Generalisability

The sample in the study is a random sample from a representative population in Sweden and could be generalised to the population of ninth grade students of age fifteen year olds. Missing data is equal from different strata groups, so no particular group of students are missing. Therefore the sample is representative for the population. For more details about missing data in the study, read article 1.

4.2 Qualitative study

The second study is a qualitative interview study combined with survey data. Analysis is both qualitative and quantitative. Analysis of interviews focuses on themes and concentration of meaning (Kvale, 1997). The themes from the interviews are described and compared to the literature on Science education, especially regarding integrated curriculum and integrated Science. The analysis of the school survey is a simple comparison of the school survey results with teacher interview results. The student survey is analysed with non parametric statistical methods (Henriksson, 1999; Welkowitz, Ewen, & Cohen, 2000).

4.2.1 Validity

The validity of a qualitative study has five validity criteria, according to Larsson (1993). The five criteria are; discourse criteria, heuristic value, empirical anchorage, consistency and a pragmatic criterion. Besides the validity criteria Larsson also mentions three criteria for the quality in a qualitative work as a whole; perspective consciousness, internal logic and ethical value. Three criteria about the quality of the results are also mentioned; richness of meaning, structure and theory development. Interviews are dependent on validity at all stages of the interview according to Kvale (1997). In the thematising of the research question the validity is dependent on the theories used and the logic used in derivation of the research questions from the theory. In the planning and what methods are used the knowledge produced is valid if it has a minimum of harmful consequences; in the actual interview the meaning and control of the information given, in the transcription of the interviews a consideration of the choice of language used is necessary, how the transcripts are made and in the analysis and assessment of the result and in the report a second assessment is needed in validating the results.

In the second study in this thesis the first five validity criteria mentioned by Larsson above have been considered. The question of integrated and traditional science is well into the discourse of science education. A description of how teachers plan and interpret the curriculum in terms of integrated and subject-specific science education in Sweden is not done earlier, so the heuristic value occurs. The empirical anchorage is satisfactory, since the school represent different ways of working. The consistency is satisfactory since the schools is a representation of one town and the pragmatic criterion can be valued by teachers that is recognising the class room situation in the second article. The three criteria of quality of the whole work have been strived for, since I have chosen a perspective from my own and others experience of teaching science in compulsory school. The internal logic in explaining the problem with integrated and subject-specific teaching has been done from different views, both theoretical and practical. Ethical considerations have been done in different steps when implementing the study, when interviewing the teachers and in writing the article and analysing and presenting data. The last criteria about quality of the results have been an ambition, as to get an as rich description of the different schools way of doing science education, making a good and easy structure to describe the teachers ways of working and trying to find a way to connect to theory about integrated and subject-specific education.

4.2.2 Reliability

One of the things that influence the results of the study are the questions asked in the interviews. Since the interviews are semi-structured there can be some differences in the questions posed to the informants. If the informants get different questions it is probable that they answer differently and emphasise different problems and areas. This is the main problem in using semi-structured interviews like the ones used in this study. One question to ask when doing interviews are 'Have things been done with reasonable care?' (Miles & Huberman, 1994, p. 278). The diachronic reliability[6] would be valued as high in this study, if referring to the teachers' examples of the planning and teaching situation. A teacher makes plans and work in according to the plan in a systematic way. A teacher that have worked for some years in the same subjects with the same year group of students usually find some kind of normal state of plan lessons in. The synchronic reliability[7] can be lower, since the teachers' view of what is integrated and subject-specific is perhaps poorly defined according to the difficulty of socially negotiated facts (see above). We tried to do each step of the interviews as well as possible. We prepared some basic questions to the teachers to concentrate what to learn about. If the teachers answered some question in an interesting manner the question was asked to be developed to get a more fulfilled description of the answer. What was judged as interesting was of course depending on what the researcher, that is I and my college, was interested in depending on the previews we came to the interviews with. Therefore the researcher is an essential part of the research instrument, as in all qualitative research.

In the teacher interviews there are results that could have been predicted that teachers do when they plan teaching like using the textbook, making a year plan, planning different year groups according to the research literature. Other results that are found are new, like the teachers using mind maps as a planning instrument and the fact that the students do not recognise the organisation of science education. To both find old 'truths' and new views are a quality in the qualitative study form. The possibility to make both confirmations of earlier known facts and find new descriptions is a factor of reliability.

The reliability of the sampling and data collection is essential in the treatment of the data, also when it come to the statistical treatment of the data. The reliability of the analysis of the results from the student survey is associated to the statistical strength of the analysis. The Mann-Whitneys U-test has a high strength if the sample does not fulfil the criteria for t-test (Henriksson, 1999, p. 99). Of course, the question of what the students are really answering can be posed since the questions can be misinterpreted. This has not been further investigated in this study. To know more about what the students really mean with their answers would require a deeper interview study. The judgement in this study is that the students have answered the questions in their best manner with exceptions that is discussed in article 2.

A discussion about the four grade Likert scale is also obvious. Why use four grades and not more steps on the scale? Why not use categorical groups, but use a scale? This is questions that can be posed in this discussion. The judgement was done that since many of the other questions in the main study where using a four grade scale, the accuracy in using a four grade scale could be made.

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[6] Stability of observations over time

[7] Stability in the same time frame

4.2.3 Generalisability

In a small case study as the one used in study 2 it is not possible to draw conclusions to a larger population. The sample is a special case of schools since they worked under the project of no set timetable. This gave the schools a larger opportunity than normal to work with freedom in the planning and performing amongst other the Science education organisation and content. The study is an example of how four schools in a small town work when they have the opportunity to abolish the timetable. The focus is on Science education and it consists of some examples drawn from the four teachers' stories about their planning and teaching. Even though it is not possible to generalise this study to all schools in Sweden, the possibility of richness of meaning of the study might lead to recognition from teachers that work in school that this is a meaningful story to read. In that case both the pragmatic validity and the empirical anchorage criteria described in Larsson (1993) are fulfilled.

4.3 Ethics

The aspects of ethics in research concerning individuals are discussed. In Sweden the research community has agreed on some recommendations for human and social research through the Swedish Research Council (Vetenskapsrådet, 2002). In these recommendations four main demands are placed: the information demand, the consent demand, the confidentiality demand and the right to use demand. Two recommendations are also posed by the Swedish Research Council: One is that the researcher should give the informants the opportunity to read ethically sensitive parts and interpretations before the report is published. The other recommendation is that the researcher should inform the informants and other involved persons where the research is to be published and be given a report or summary.

In the PISA project the students receive information sent to them before the assessment instruments are distributed to them and the assessment takes place. The parents to the students have the opportunity to withdraw the participation if they find it uncomfortable or not suitable for their children to be assessed. The sampled schools of the PISA study are obliged to participate, since the assessment is managed by the Swedish National Agency for Education, who has the commission to evaluated schools. The international comparison assessment is used as a part of the national evaluation system. The schools that answered the questionnaire that I sent to them in study 1 were not obliged to answer this specific survey, so the response rate of 77 percent of possible schools is a satisfying result. The students' results from the PISA assessment are made anonymously and no personal results are published.

In study 2 the teachers were informed orally about the interviews and could refuse to be interviewed. The schools and the teachers are presented anonymously in the presentation. The same procedure as was used in the PISA 2003 assessment was applied to the student survey in study 2.

Finally the data gathered in the two studies is not presumed to be particularly sensitive for the informants. The potentially sensitive data concerns the individual student and his/her results. This is handled with care and confidentially throughout the PISA process.

5. Results and discussion

5.1 Study 1

The first study contains a quantitative data of a number of schools in the PISA 2003 study that work with integrated Science or subject-specific Science or a mix of both. The sample is analysed both on an individual basis and at the school level. Simple mean comparison and multiple regressions have been performed on the data. Results from this study have been published as a poster presentation showing that small schools use integrated Science more often than large schools (Åström, 2004). A poster presentation showing that different organisations (integrated, subject-specific and mixed) do not produce different individual student Science results in PISA 2003 (Åström, 2005). An article using hierarchical linear modelling that examines factors that may interact with the teaching organisation of Science education. The article of the hierarchical linear models is found in this thesis as one of the enclosed articles (article 1).

The results of article 1 are that there is no differences in students' science results from the PISA 2003 investigation between different organisations of Science education (integrated, subject-specific or mixed) when using a hierarchical linear model. This is statistically significant also when different factors such as economic, social and cultural index, language spoken at home, country of birth and that type of variable is taken into account. For more details about the study of hierarchical linear models, it is recommended to read article 1.

Probable reasons for the lack of difference are discussed in this section. Reasons for the lack of difference due to teaching organisation are discussed thoroughly. Coherence in school answers is evaluated and the variables for this study are sharpened. Explanations for the lack of differences due to the statistical treatment are explored. A selection from the sample is briefly compared to another project and a possible objection to the study is discussed.

5.1.1 Sharpening the variable of teaching organisation

One explanation for the lack of difference between different organisations in Science education is uncertainty about what informants meant when answering questions about teaching forms in Science. To find out more about the coherence between descriptions of teaching and other related factors, we studied the extent of agreement between the information about teaching forms in Science (classified in a survey in autumn, 2003) and subject grades from spring, 2003. Schools are allowed to give students grades either in general Science (NO) or separately in Biology, Chemistry and Physics. These subject grades are found in the SIRIS database (Skolverket, 2006b). Schools that gave students general Science (NO) grades were categorised as integrated and schools that gave students separate grades in Biology, Chemistry and Physics were categorised as subject-specific; schools that gave students grades both in general Science and in separate subjects were categorised as mixed. Table 1 shows the subject grades schools give students compared to the schools' answers to the survey of autumn, 2003.

	Grades			
Teaching organisation	**Biology, chemistry, physics**	**Science grade (NO)**	**Both biology, chemistry, physics and science**	**Number of schools**
Subject specific	**75**		**4**	**79**
Integrated	**10**	**11**	**1**	**22**
Mixed	**23**	**1**	**7**	**31**
Number of schools	**108**	**12**	**12**	**132**

Table 1. Results of the school survey from autumn, 2003 compared to subject grades from the SIRIS database.

To understand this table, we can look at the first cell. This shows the number of schools that work subject-specifically according to the survey of autumn, 2003 and that give students grades in Biology, Chemistry and Physics. From cell to cell we see the number of schools (according to the survey of Autumn, 2003) that work with one or another method of organising teaching: integrated, subject-specific or mixed and what grades they actually give to students in subjects (separate grades in Biology, Chemistry and Physics, grades in general Science(NO) or mixed grades). When summing up schools grading Biology, Chemistry and Physics and having subject-specific teaching, schools grading science (NO) and having integrated teaching, and schools grading mixed and having mixed teaching we get 93 schools. This is 70 percent of the 132 schools answering the survey of autumn, 2003. We can see from this table that 70 percent show consistency between their answers regarding the organisation of Science and the grades they actually give. This may seem to be of little importance for the schools Science education but it may be a major problem in a study like this since the variable 'teaching organisation' is not sharply defined and it is difficult to use statistically.

Therefore the variable 'teaching organisation' was refined by cross-matching the schools' answers with actual grades given to students.

The result of this refinement of the variable produces small student groups in some cases. The proportion of students in the group with refined variables is 71 percent of the main group (from the total of 1867 used in article 1). The group of students having mixed teaching in Science is only 26 students out of the whole sample. This may appear unreasonably small since there were seven schools in this group from the beginning but on an individual level only three schools contributed to this group. Students with integrated Science and grades in general Science (NO) represent a more moderately sized group of 150. Students with subject-specific Science and grades in Biology, Chemistry and Physics represent the most common situation (1156 students in all). Only two percent of students in this sample fall into the mixed category (integrated or subject-specific teaching and grades in general Science (NO) or in three separate subjects). An attempt to model a hierarchical linear model with this sharpened variable yielded no differences in students' results in scientific literacy in the presence of different Science organisations, just as in the models built with the variable used in article 1.

Informants had difficulty defining teaching organisation. This may be due to the researchers' imprecision but it may also have other causes. A list of different explanations as to why the investigated variable of ways of organising Science teaching does not produce differences in student results is given in article 1.

5.1.2 Comparison with the project with no set timetable

A comparison was made between a sample of twenty-nine schools involved in a five-year project with no set timetable and the PISA 2003 study. Not all of the twenty nine schools answered the survey of autumn, 2003. In the sample used in analysing student results in article 1, 13.7 percent of the students were involved in the project with no set timetable. This is a lower percentage than in the PISA 2003 study, where the proportion of students was 17.1 percent. In the project with no set timetable 20 percent of the schools in Sweden participate. 19 schools answered the survey of autumn, 2003 which is to say that ten schools did not answer this survey. Attempts to compare statements from schools that both participate in the project with no fixed student schedules (SOU 2005:101, 2005) and participated in the survey of autumn, 2003 shows once again the difficulties involved with describing and defining integration in schools. Schools write one thing in their report to the government and another thing in their answer to the survey of autumn, 2003. In short, it isn't easy to know how schools work with Science in a survey like this.

The results of this study show that there is no difference in students' Science test results due to the form of teaching in Science. Integrated learning is designed to enhance students' ability to learn, as discussed in section 2.3. A possible explanation for the discrepancy is that PISA 2003 measures Science result in a way that does not show the students' ability to learn. Another possible explanation for this lack of difference is that integrated Science education is not producing the higher student results some proponents for integrated learning predicted. The second explanation is similar to earlier studies (Andersson, 1994a).

5.2 Study 2

This study deals with teachers' and students' perceptions of Science education. The teachers' views are concentrated on planning and content. The students' views are concentrated on three questions on integration of Science. The study used different data: interviews with teachers, classroom observations of teachers, a school survey and student questionnaires. Teacher interviews were analysed for integrated or subject-specific Science education and the students questionnaires were analysed statistically. Two of the four schools in this study are categorised as integrated schools, one is subject-specific and one is mixed. The different ideas about the planning and teaching are described in article 2, with examples of how the teachers work, taken from the interviews and classroom observations. The most striking difference between integrated and subject-specific teaching is that integrated schools work with planning mind maps and with projects or themes. The subject-specific school does not use these tools in planning and teaching. Apparently students' views of subject-specific as opposed to integrated Science do not completely coincide with teachers' views. This is found when analysing the students answer at a student survey with non-parametric statistical methods. For more details about Study 2, it is recommended to read article 2.

This section of the thesis contains a second analysis of the results in article 2 with a conceptual framework that is borrowed from the TIMSS study. This framework consists of three levels of actors in the school system that do not coincide and can have different perspective on work in schools. This section also contains a brief discussion regarding the fact that the four schools participating in the project have no set timetable.

5.2.1 Second analysis with TIMSS conceptual framework

An attempt to gain a second perspective on the results in article 2 is obtained by analysing it in the light of the intention-outcome model used in the TIMSS study (Robitaille et al., 1993), se also section 2.2 in this thesis. The main idea behind the conceptual framework is that the education in school exists in an environment that is larger than just a single school. To define this environment is not easy and not always distinct. This is because the different environments are interacting and interchanging. The conceptual framework of TIMSS includes three different levels of institutional arrangements within three different societal contexts, and is chosen as a simple and still sufficient frame to do a second analysis within. The three levels are; intended, implemented and attained curricula.

The intended curriculum is Science defined at the national or school level and has a society-at-large environment. The intended curriculum is embedded in textbooks, curriculum guides, examinations, policies, regulations and other official documents designed to direct the educational system, for more details about the intended curriculum, se section 2.2. The context for the schools in article 2 is that schools have a national, a municipal and a school curriculum as the intended curriculum. The intended curriculum is not much described in article 2, mainly because the national curricula in Science, Biology, Chemistry and Physics are written in a way that both permit integrated teaching and subject-specific teaching. Due to the curricula it is also free for the teachers to choose how to work. The documents at national, municipal and school level are linked but since schools function under different conditions (organisation, economics, human resources), they plan work according to circumstances. It is therefore more interesting to see how teachers plan and work than to know what it is possible to do. Therefore the implemented curriculum becomes a larger part in this study, than the intended curriculum.

At the community level the implemented curriculum is Science content as it is presented by teachers to students. The focus of the implemented curriculum is the school or classroom. This includes teaching practices, aspects of classroom management, the use of resources, teacher attitudes and backgrounds. In article 2 we see that more than one aspect of the teachers come into play when teachers work out plans and arrangements for students' Science education. A teacher works with the skills in his or her possession to achieve the best possible Science education. The implemented curriculum is studied using the teacher interviews with a focus on the question of integrated and subject-specific Science teaching. The classroom observations are used as an additional source to compare the teachers' stories about classroom work with the implemented curriculum. From the classroom observations it is not an easy task to find differences between the different organisations of integrated and subject-specific Science education. The teacher interviews are more expressional of the aims and wishes of the teachers as to how they would like to work.

The attained curriculum is the outcome of what the students are learning, both results in a specific subject and also attitudes towards the subject. It stems from the schooling, concepts, processes and attitudes towards Science that a student acquires in school. What students learn is influenced by what is aimed at (that is the intended curriculum in the terms used in the conceptual framework) and the quality and types of opportunities made available to them, mostly presented by the teachers as the implemented curriculum. It also depends on the institutional arrangements such as amount of homework, efforts by the student and student classroom behaviour patterns. The students' personal background influences the outcome of studies. In article 2, we see from the survey that students lack clarity about the teachers' purpose in organisation in at least one of the schools. In one of the schools (school A) students perceived the teacher's strive as being towards integrated science, with themes of different kinds. In another school, students perceived the teacher's purpose as being towards subject-specific Science with no themes (school C). In the two other schools (school B and D), students had not perceived the teachers' aims in Science education organisation. The attained curriculum regarding the teaching organisation of Science education is therefore different between students at the different schools.

The result in study 2 that the students do not perceive the teachers' purpose when concerning integrated as opposed to subject-specific Science teaching is of no consequence to the Science knowledge since student results were the same regardless of teaching form, as evidenced by article 1. Nevertheless, students' lack of perception in this area is remarkable, since they are working in Science but do not have names for how they work. How is it possible to work in an environment not knowing the names of the working organisation?

More important outcomes of the attained curriculum than perceptions regarding teaching forms are: the emphasis students experience on Science education in the form of everyday coping, structure of Science, Science, Technology decisions, scientific skill development, correct explanations, the self as explainer and solid foundation (Roberts, 1988). What signals does the student get from the teacher and the subject?

In article 2 one difference between experienced and inexperienced teachers is pointed on. Teacher experience may affect student confidence in expressing views regarding teaching style (integrated or subject-specific), but it is difficult from this study to make a generalised result that the experience of the teacher is the reason for the students' answers as to what kind of teaching organisation they have. The students in this study with experienced teachers are more confident about what kind of science education they have (integrated or subject-specific) than students with younger teachers.

5.2.2 Project with no set timetable

The four schools studied in article 2 share the same national and local curriculum and they all participate in the project with no set timetable. Nevertheless, they have quite different ideas on how to plan the work with Science education and they make use of their freedom to choose forms suitable to local conditions. As a result of this, two schools work in an integrated way in Science, one works subject-specifically and one works with a mixed form. Study 2 does not succeed in determining if integrated or subject-specific teaching produces better fulfilment of objectives but it illuminates how integrated and subject-specific Science education work in practice.

5.3 Summary

The conclusion of the first article is that there are no differences in student results in scientific literacy when student groups with different teaching organisations are compared. This study is including individual background factors as gender, country of birth, home language, preschool attendance and an economic, social and cultural index, but the variable of teaching organisation is not contributing to the difference in students' results in a statistical significant way. In the study the starting point was to investigate the two teaching organisations integrated and subject-specific Science in Sweden but it became necessary to include a third, mixed organisation. The division of the teaching organisation reflects the fact that subject grading may be done in two ways in Sweden. But this administrative issue of grading is not the only cause of different teaching organisations in Science, the forces to accomplish integration and subject-specific science is not that simple as explored in section 1.1 to 1.6 in this thesis. There are also ideological, political and perspectives of knowledge involved in deciding whether to integrate Science or not, besides the organisational issue. However, student grading allows us to perceive different organisational forms at the school level.

Answers collected from the schools in the survey of autumn, 2003 show that schools differ in their work with Science education, as presented in section 5.1 and article 1. In the survey of autumn 2003 the occurrence of different teaching organisations became evident, and a deeper understanding of what the different teaching organisations looked like was sought. A detailed presentation of the differences in integrated as opposed to subject-specific Science education was impossible to obtain from the 132 schools studied in the PISA 2003 survey. Therefore a second study of teachers' and students' views of Science was conducted as described in article 2. This second study was performed to get a more detailed picture of the teaching organisation of Science education and to find similarities and differences in these organisations. The results of the second study show that there are differences between integrated and subject-specific schools in the first place, at least in the schools that were studied in article 2. The main difference is that the integrated schools in this study work with themes or projects. The subject-specific school in this study works with the textbook in a traditional way. Similarities between the schools are that they all make overall year plans in the work team that are broken down by the teachers into lesson plans. The overall plan looks different in the integrated and the subject-specific schools in this study. The integrated schools use a mind map of the themes in the weekly work. Since there are no themes in the subject-specific and mixed schools, they do not use a plan with themes.

The two schools in this study that work with integrated Science have different ways of interpreting the curriculum in Science. They work differently, one school using mainly teacher-planned themes and the other school using student-centred planning. The students perceive the curricula differently; at the second school, students' claim that they do not work integrated while the teacher maintains that integrated teaching permeates all classroom work.

Study 2 found that some of the work at the lessons in Science classes is similar, regardless of teaching organisation. The similarities are mainly in the intended curriculum, which is approximately the same for all schools studied. They all have the same national curriculum interpreted at the local level, they are all in the same development project and they are all in the same municipality. Differences between the schools consist mainly in implemented and attained curriculum. Teachers have different ideas about how Science education should be planned and performed. This obviously creates differences in the implemented curriculum. The students differ in how they attain integrated and subject-specific Science organisations. This is a difference in the attained curriculum.

5.4 Discussion of the results

There are at least three possible explanations of the lack of differences in students' Science results. The first is that there are more similarities than dissimilarities between integrated, subject-specific and mixed organisations in Science education and the similarities are more decisive than any particular organisation of Science. Put in another way, the differences in teaching form contributes less to student results than elements common to all the teaching forms. A second explanation of the lack of differences is that the division of Science education into integrated and subject-specific Science is not an aspect that is of significance for giving differences in students' results in scientific literacy. A third explanation is that the teacher plays a major role in student results; this factor cannot be foreseen in investigations of this kind.

5.4.1 Difficulty with the variable

The variable used in study 1 explains the proportion of schools and teachers working with an integrated, subject-specific or mixed organisation. It is also possible to find out that there are different ideas about how to work with Science in compulsory schools in Sweden, according to the answers the schools gave in the survey of autumn 2003. The variable is not sharp and well-defined, but has some differences in interpretation according to the informants. This is also seen in study 2, where the teachers have different ways of implementing Science according to the interviews. The implementation is different even if the teachers' labelling of the organisation is clear, as is seen in study 2. The teacher in School A, that works in an integrated organisation works with projects, and the teacher in School B that works in an integrated organisation works with themes. They both work in an integrated organisation, but have different interpretations of how they like to work. That there are differences between the teachers' ideas of implementing Science education can be seen in the differences in planning the Science lessons between the teacher in School C that works subject-specifically and the teachers that work with integrated Science in Schools A and B.

The variable explored in this thesis for understanding Science organisation had a problem. The problem was that there was not enough agreement between different views of looking upon Science education organisation. This is a common problem with social facts (Searle, 1995). Maybe this problem could have been foreseen by the researcher and had been circumvented if the researcher had created an exact definition of the term that teachers could easily answer to. It is still not certain that differences would be found between the different Science organisations, since there are other difficulties also involved in the definition of the variable.

5.4.2 Is the division between integrated and subject-specific artificial?

The second explanation to that there are no difference found in students' results from the categories in this thesis is the problem that maybe the division of teaching organisations is somehow artificial and of no significance. Integrated Science is not an easily defined and simple variable that all teachers agree upon. An explanation for this is the complex and multifaceted situation in the classroom. A second explanation can be that teachers shift strategies to meet student needs (Bennett, 1976; Davies, 1972); maybe integration as opposed subject-specific teaching is unimportant in this light. Teachers' roles are developed further in section 5.4.3. A third explanation of the difficulty in defining the variable of integrated or subject specific science is the infected political debate that surrounds these issues in Sweden.

The organisation of an optimal Science curriculum was discussed in the early stages of curriculum discussions in the USA, as Wraga writes in his historical exposé (Wraga, 1997). Although previous tests in Sweden show no increase in students' cognitive knowledge there is an increase in student interest when they are exposed to integrated teaching (Andersson, 1994a). The lack of difference in student results due to different teaching organisation indicates that integrated teaching may not be as import to students' knowledge as some authors believe. Studies in the 1970's have shown this to be the case (Aitkin, Anderson, & Hinde, 1981; Bennett, 1976) as well as studies in the 1990's (Andersson, 1994a). This study presents results that confirm those found in the Bennett and Andersson studies, even though this study uses different assessment assumptions (OECD, 2001, 2003) and different analytical methods.

Some factors, such as the economic, social and cultural index, are statistically significant in explaining differences in students' Science test results (Willms, 2001, 2003).

If teachers are not clear about the underlying ideas governing positions they are supposed to work with, they might either find it difficult to take a stand or embrace the dominant ideology without hesitation. The progressive idea, that the child is the one learning and that education should be adjusted to the child has its roots in Rousseau and was developed by Dewey (Dewey, 1938/1997). But what if the implementation of this ideology gets out of hand, what if students get the better of the teacher and work in the classroom gets out of hand? This is a problem that is discussed repeatedly in the Swedish political debate. Order in school and more restrictive rules for students is demanded, mostly from a liberal standpoint (Leijonborg & Björklund, 2006).

5.4.3 Teacher's role

The third explanation to the lack of difference between different teaching organisations is partly understandable from results of a study of teacher interviews in a single municipality (Åström, 2006). The teachers work in a pragmatic way to solve difficulties that occur in their daily work (James, 2006), and this pragmatic way is not always in a clearly defined learning or teaching theory. Therefore the difficulty in defining how to name their organisation is not simply a question of semantics. This means that the implemented curriculum in Science education differs from school to school and from teacher to teacher. This is not peculiar to Sweden; similar results have been noted in other countries (Venville, Wallace, Rennie, & Malone, 2002). The diversity in defining what an integrated Science curriculum is has been reported earlier (Haggis & Adey, 1979) and there is nothing to suggest that this diversity has diminished over time.

Schwab has written about the complex and multi-faceted teaching situation (Schwab, 1954/1978). He writes of the trust and respect the teacher must create in students to overcome disciplinary problems and the teacher's need of respect as an adult whom students can lean on, learn from with whose help they can become interested in the content and problems posed at school. Interest is Schwab's focus in this particular essay and he describes how teachers can reflect on generating interest with the students. Awakening student interest is not a simple task, particularly since the interests and views of different actors in schools do not coincide, as Roberts points out (Roberts, 1988). Tobin discusses the importance of forming a classroom culture that enables students from all social and economic groups to learn the required amount of scientific literacy (Tobin, 1998).

5.4.4 Further research

Since only four schools are studied in article 2 and only one works subject-specifically, it is not possible to compare schools with subject-specific teaching to determine differences and similarities in planning, teaching and students' perception of the Science education. The same applies to schools with mixed forms of Science education. A study containing more schools could reveal some specific characteristics of integrated and subject-specific teaching and provide a more distinct variable to use when comparing students' results with different teaching organisations.

A large five year project is being conducted in Sweden to investigate the use of no set timetable (SOU 2004:35, 2004; SOU 2005:101, 2005). The conclusion of this project is that it is indeed possible to work with no set timetable. This conclusion is based on self evaluations from the schools and on students' results. A school with no set timetable could be a way of achieving an integrated curriculum but worrying signs have been ignored by this investigation. Some of these signs are concentration on the core subjects of language, English and Mathematics (Eriksson, Orlander, & Jedemark, 2004), and the lowered results in Science among the lowest achieving students in the PISA 2003 study (Karlsson & Åström, 2005). The trend towards increasing differences in study results between students with high and low socioeconomic statuses is an undesired development and it has been studied (Skolverket, 2006c). An additional research question is how integration is affecting and is affected by work with no set timetable.

One question in the debate is if all levels of education should be integrated. In this context, Musgrove's thoughts about integration and specialisation mentioned in section 1.2 are interesting (Musgrove, 1973). He writes that integration can become pathological in some forms. Shamos is another author that has discussed difficulties with integration (Shamos, 1995), the risks of shallowness and insufficient student results. An investigation of the appropriate level of integration in schools is therefore of interest.

Riis (1985) points out that integration as opposed to subject-specific curricula has been a common thread in Swedish curriculum discussions since the mid-twentieth century. Different actors have supported differing views; see Lövheim (2005, 2006). This struggle has been ongoing throughout the twentieth century (Lövheim, 2005; Wennberg, 1990).

It may be asked if the division of Science education into integrated and subject-specific is appropriate. The issue of Science education may perhaps be looked at quite differently, for instance in terms of content and context (Fensham, Gunstone, & White, 1994), or in terms of the effect of the curriculum on content (Östman, 1998).

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FontD, the Swedish National Graduate School in Science and Technology Education Research gave me a start in my PhD education to become a researcher. Thanks Professor Helge Strömdahl, head of the school, for challenging my pre-concepts of what Science education is and helping me develop myself to become a better researcher. The world wide contact net of Science education researchers at FontD has been very rewarding to get to know and listen to in lectures and informal discussions.

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Appendix 1

Maria Åström Härnösand 2003-09-30

Doktorand i NO-didaktik
Institutionen för teknik, fysik och matematik
Mitthögskolan
871 88 Härnösand

Angående undervisningens uppläggning i naturorienterande ämnen (NO) på er skola läsåret 2002/2003

Jag är doktorand på Mitthögskolan i Härnösand och arbetar med forskning om elevers kunskaper i NO i grundskolan. Som en del i mitt doktorandprojekt vill jag komplettera de data som insamlats till PISA 2003 med en ytterligare fråga. Jag hoppas att ni på skolan kan besvara denna fråga och snarast, dock senast **13 oktober** sända tillbaka enkäten på ovanstående adress.

Undervisningsgrupp syftar på de av er angivna undervisningsgrupper som hade elever som deltog i PISA-studien under våren 2003.

I kolumnen Tema- eller ämnesundervisning markerar ni hur undervisningen i huvudsak har bedrivits i undervisningsgruppen under våren 2003.

I följande kolumner anger ni namn och e-post till undervisande lärare i gruppen. För de grupper som haft en lärare i NO som arbetat med temaundervisning/integrerad ämnesundervisning anges namn i kolumnen för temalärare. För de grupper som haft lärare som undervisat i uppdelade ämnen i kemi/biologi/fysik anges namn i de för dessa kolumner angivna.

Var vänlig att uppge undervisande lärare från våren 2003, även om vederbörande inte längre finns kvar på skolan.

Vänliga hälsningar
Maria Åström

Enkäten finns på baksidan av detta brev

Undervis-ningsgrupp	Tema- eller ämnesunder-visning i NO (T eller Ä)	Namn och e-mail för Tema-lärare	Namn och e-mail för lärare i kemi	Namn och e-mail för lärare i biologi	Namn och e-mail för lärare i fysik
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