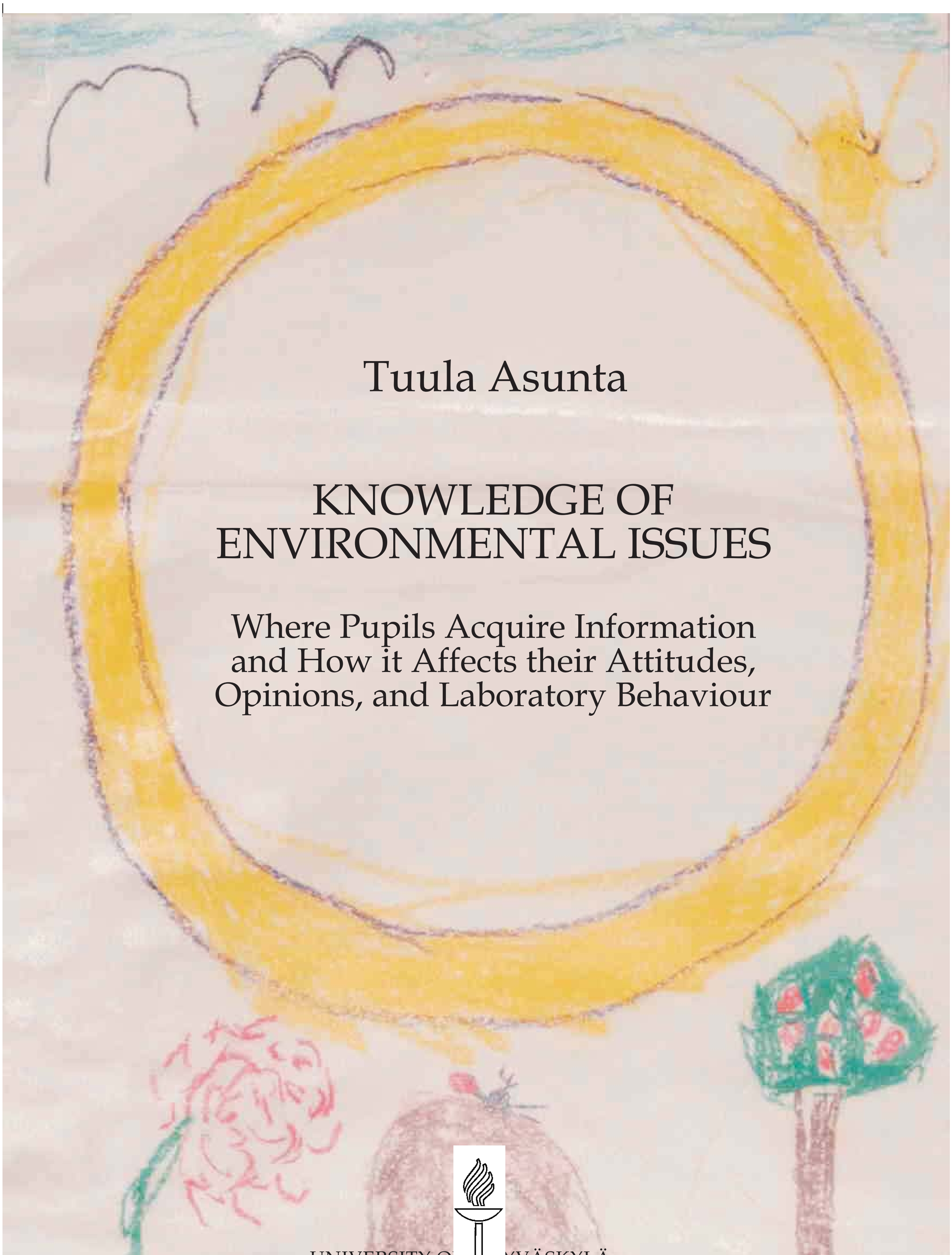

Tuula Asunta

KNOWLEDGE OF ENVIRONMENTAL ISSUES

Where Pupils Acquire Information and How it Affects their Attitudes, Opinions, and Laboratory Behaviour

UNIVERSITY OF JYVÄSKYLÄ
JYVÄSKYLÄ 2003

JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 221

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UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2003

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Dedicated
To the memory of my dear mother
and sister Terttu

Tuula Asunta

Virtaava joki

Joen kirkas vesi virtaa
Siinä purossa,
Joka laskee jokeen.
Alajuoksulla lohet hyppivät.
Kalastajakin on siellä.
Kalastaja saa yhden lohen kiinni ja
Rupeaa sitä perkaamaan.
Sitten hän paistaa sen - ja syö.
Lohet laskevat kutunsa siihen
Ja ne kuolevat, kun ovat tulleet
Pitkän matkan yläjuoksulle.
Kutu muuttuu poikasiksi
Ja niistä tulee uusia lohikaloja.

JOKI SOLISI JA LORISI
JA PIKKUKALAT HYPPIVÄT

Onnea äidille!
Oskari Asunta, 6 years, 1990
(eskarin opettajan muistiin kirjoittama)

The flowing river

The clean water of the river flows
In that stream,
Which empties into a river.
In the lowe reachers the salmon leap.
There is a fisherman there, too.
The firsherman catches a salmon and
Begin to eat it.
Then he fries it - and eats.
The salmon spawn there
And they die, when they have travelled
A long journey upstream.
The spawn changes into young fish
And they into new salmon.

THE RIVER BABBLES AND GURGLES
AND THE LITTLE FISH LEAP

Every happiness, mother!
Oskari Asunta, 6 years, 1990
(written down by his pre-school teacher)

ABSTRACT

Asunta, Tuula
Knowledge of Environmental Issues. Where Pupils Acquire Information and How it Affects their Attitudes, Opinions, and Laboratory Behaviour
University of Jyväskylä, 2003, 159 p.
(Jyväskylä Studies in Education, Psychology and Social Research,
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Finnish Summary
Ympäristöasioita koskeva tieto. Mistä oppilaat saavat informaatiota ja miten se vaikuttaa heidän asenteisiinsa, mielipiteisiinsä ja laboratoriokäyttäytymiseensä
Diss.

This study concentrates on the area of environmental education and environmental attitudes and behaviour. The main purpose of the study is to pay attention to the environmental knowledge of students as well as to explore the environmental concerns attitudes and behaviour of Finnish secondary level students in order to be able to educate environmentally concerned and aware students through developing teacher training. As a comparison the environmental knowledge, attitudes and self-reported behaviour of students of one German school were studied. Promoting environmental awareness as well as an environmentally responsible lifestyle can only be realised through information, and therefore students' main information sources on certain general environmental issues were studied and analysed. The changes during the years 1994 to 2000 were examined. Four schools in Finland representing different areas participated in this study and, against the background of the Bologna agreement on the equalisation of education in European countries and in order to gain some international perspective in this study, one large school from Frankfurt-am-Main was included.

In this study teacher interviews, two written questionnaires as well as classroom observation and videotaping were used to acquire information. The pupils involved included secondary level pupils, meaning class grades 7, 8 and 9 in Finland and grades 8, 9 and 1 in Germany. The total amount of 883 students (243 German and 640 Finnish) participated in the main part of the study, which consisted of two types of written questionnaire. These written tests were introduced in 1994-1996 and 2000. The German students only took part in the written tests.

The study clearly stated that the main important information sources on environmental issues for secondary pupils are mass media and science teachers. It also proved that environmental concepts are very familiar to students and that most students have slightly more confidence in the information gained from television than from their science teacher. According to the study, the difference between schools in Finland concerning students' general environmental attitude was almost significant. This difference was mainly due to two schools in Central Finland. It was quite astonishing that students' environmental attitudes in the country school proved to be more negative than in the suburban school.

The very alarming finding in this study was that students' attitudes towards studying chemistry, as well as towards chemistry and the chemical industry in general, have become more and more negative during the five-year period of this study. In general boys' attitudes towards chemistry and the chemical industry were more positive than girls'. Within those German students representing just a random sample from one school in Frankfurt-am-Main boys' attitudes seemed to be significantly more positive than girls' in both the 1996 and 2000 studies and the difference has increased since the girls' attitudes have become more negative, just like in Finland. The general negative attitude towards studying chemistry has grown in both countries.

The study gave no evidence that either a positive environmental attitude or positive general environmental behaviour leads to environmentally responsible behaviour in the chemistry laboratory.

Key words: attitude, environmental attitude, environment, environmental knowledge, environmental education, environmental information, environmental behaviour

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I feel that I have been very privileged to be able to work for my second thesis in the educational area.

I did my first thesis in chemistry in 1980. This work has been very different from my first thesis, which was based on very strict data and did not leave so much room for interpretation. I do not know which one has been more pleasant, but I have to admit that I have really enjoyed doing this educational research. Even if it has given me some moments of frustration, it has also given moments of joy and enthusiasm. Originally, I planned that this work would be completed much earlier than this, but in retrospect maybe this is better: I have had time to process all the information available and my own results.

I feel that I owe sincere thanks to many people who have been helping me through this work. First of all, I would like to express my sincere thanks to my supervisors, emeritus professor Jouko Kari and professor Hans Joachim Bader, for the guidance and support they have given me during these years I have been struggling with my work. Professor Kari helped me to see some important points concerning the methodological part and discussion. My deepest thanks are due to professor Bader, who originally encouraged me to start my thesis in this area and gave me valuable advice when I was planning my research as well as constructing the questionnaires. He also gave me valuable advice concerning my way of presenting the results. Even though he later gave me a hard time by advising me to use factor analysis, that I was not so familiar with, I must admit that without his help I would not have seen the different sides of my results.

I am very grateful to professor Varpu Eloranta, who acted as the pre-reviewer of the thesis and helped me to discover several weaknesses in the manuscript. Her contribution greatly increased my awareness of several theoretical and methodological aspects of the thesis. To Dr John Parkinson, who was the other pre-reviewer, I also owe my sincere thanks. He read my thesis very carefully and pointed out several grammatical corrections. He also raised some methodological aspects.

My warm thanks to my coworker, lecturer Glyn Hughes. I greatly appreciate his contribution since he gave me, in spite of his numerous other duties, his valuable help by polishing my English further. I also give my gratitude to lecturer Marja-Leena Koppinen for her constructive suggestions concenrning Finnish summary.

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Palokka, June 2003

Tuula Asunta

CONTENTS

1 INTRODUCTION

1.1 The purpose of this study

The main purpose of this study was to pay attention to the environmental knowledge of existing and future students and their environmental concern, attitudes and behaviour in order to develop teacher training of science teachers based on the results of this research. One purpose was to see the changes in pupils' knowledge, concern, attitudes and behaviour during the period 1994 to 2000.

Environmental concern is common to us all, in Finland as well as in other countries and we should work together, using all different ways that each scientific area offers to solve environmental problems. The students of today are the key to the future when we talk about solving environmental questions. Studying young people's environmental attitudes is particularly important since they are the ones who will be affected by those environmental problems that will arise from our current actions of today. They also have to provide solutions for those problems and pay the costs of developments.

The evolution of environmental education over the past two decades has brought with it a host of questionnaires, surveys, and scales designed to measure people's knowledge of or attitudes and behaviours toward environmental issues. Because a majority of the studies have scales whose validity and reliability are often questionable, meaningful comparisons among investigations in the area are difficult.

As Leeming and Dwyer (1995) have pointed out, the availability of a carefully developed and psychometrically valid scale to measure children's global environmental attitudes and knowledge would be a valuable teaching and research tool. They detailed the construction and preliminary validation of the **Ch**ildren's **E**nvironmental **A**ttitude and **K**nowledge **S**cale (CHEAKS). The CHEAKS appears to satisfy the need for a scale to measure children's global attitudes and knowledge concerning environmental issues.

Ebenezer and Zoller wrote in their article (1993, 175):

> For meaningful learning of science and understanding its relationship to reality and every day life, the proponents of the constructivist approach assert that learners, through the use of their existing knowledge, interpret new information in ways, which make sense to them. The teacher's role is to be a constructor of the conceptual bridge between the student's point of view and the intended objectives of science teaching.

Teachers have to raise questions on environmental issues especially since today all up-to-date teachers have changed their traditional role from that of provider of knowledge to that of fellow-learner, reciprocator, and negotiator. Environmental issues offer a wide field of variety of learning and discussing environmentally important phenomena.

1.2 What this study discusses and why

The present study discusses pupils' attitudes toward environmental issues, their environmental knowledge, sources of environmental knowledge and students' behaviour in the chemistry laboratory during certain activities. Since the literature on attitudes is enormous, I shall only shortly introduce the general features of attitudes and restrict my theoretical framework to consist only of the environmental attitudes that my research study concentrates on. Studying young people's environmental attitudes is very important because they are the ones who will be affected by and will have to provide a solution to environmental problems arising from our generation's current actions. According to several research findings girls are more likely to worry about the environment than boys (Rockland 1995; Burger et al. 1998). Burger and others recorded that women were more willing to preserve rain forests, remove lead from drinking water and solve the ozone problem than men. It seems that females are more in favour of so called "soft values" than men. Recycling, air pollution, and littering are environmental issues that students say they know most about. In the end of the1990s American students seemed to be most interested to know about the damage of the ozone layer, endangered species (plants and animals), and global warming. Young children reported the highest level of knowledge about the environment at that time and they also thought that the quality of environmental education at school was at a high level contrasting with high school students who reported the low quality of curricular environmental education. In the beginning of 2001 Finnish girls turned out to be as interested as boys in many general environmental issues, even though they were presented by means of some technology, such as CD-ROMs (Kari & Nöjd 2001).

Since the 1970s the environment has been an important public issue, and one result has been a large number of studies of people's attitudes toward environmental issues, their environmental behaviour and environmental knowledge. In their book Cushman and McPhee (1980, 3) have provided an overview of and background to the relationship between attitudes and behaviours. Their definition of attitude is:

> Attitude is thought both as a predisposition causing consistency in behaviour, and so as a general evaluation of an object, measurable by questionnaire. Clearly, if attitude is defined as a predisposition or a preparation to behave, it is at least a necessary condition for behaviour; the link between attitude and behaviour is necessary and must exist empirically if valid measures of attitude and behaviour are used. But if attitude is affective orientation, it is hard to find any compelling reason to expect behaviour to reflect or even be consistent with an attitude. People might or might not act on the basis of their feelings, and if they do, the interesting phenomenon requiring an explanation is why they act in this way.

In their book Cushman and McPhee (1980) mention the development of attitude- behaviour theories and theoretical models developed; for example, that of Fishbein and Ajzen (1975), which is described later in this work, and they discuss the approach of such theories. It would be, however, another theoretical thesis to discuss all the arguments and opinions, related to the theories proposed by researchers. Those who are interested can get a good overview by reading Cushman and McPhee's book.

2 ENVIRONMENTAL ATTITUDES AND BEHAVIOUR

Many approaches have been used to predict and understand specific behaviour of people. There is a huge amount of literature available dealing with environmental attitudes and behaviour. An attitude is seen as a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour. Olson and Zanna (1993, 118) reported that "attitude and attitude change remain among the most extensively researched topics by social psychologists". According to the literature many researchers starting from the beginning of 19th century have tried to describe attitudes, among them Karvonen (1967), who studied the structure, arousal and change of attitudes of teacher education students. There is also a huge amount of literature dealing with people's environmental attitude and behaviour. This research focuses on young people's attitudes towards, and behaviours in relation to the natural environment. Attitudes in this research are defined as the enduring positive or negative feeling about issues concerned. Environmental behaviours in this study are seen as "pro-environmental behaviour" determined by Kollmuss and Agyeman (2002, 240):

> By 'pro-environmental behaviour' we simply mean behaviour that consciously seeks to minimise the negative impact of one's actions on the natural and built world (e.g. minimise resource and energy consumption, use of non-toxic substances, reduce waste pollutions).

2.1 Approaches to attitude measurement

First, I will briefly introduce the general features of attitudes based on the literature. It is difficult to cover the enormous amount of complex attitude research literature in this thesis.

Many researchers starting from the beginning of 20th century have tried to describe attitudes (Thurstone 1929; Kiesler et al. 1969; Ajzen & Fishbein 1980b; Ajzen 1988; Crawley & Koballa Jr. 1994). The word attitude means originally suitability or adaptability (Allport 1970) and according to the oldest definition it is the mental state founded on experience that directs peoples' reactions towards the object associated with the attitude (Kolb 1984). Attitude can also be defined as a positive or negative attraction to a certain object. According to Puohiniemi (2002, ix) environmental attitudes are the ways to know how to be in a proper relationship to one's environment. Attitudes can be a positive, neutral or negative readiness to act in deciding how to act in a certain situation.

Cook and Sellitz (1964) claimed that attitudes, on their own, do not control behaviour: they enter along with other influences into the determination of a variety of behaviours. Most researchers have agreed that attitudes have three components: (1) knowledge (cognition), (2) feeling (affect) and (3) tendency towards action (behaviour). A number of researchers have attempted to disentangle these three components, and show how they relate to each other (Rosenberg 1956; Hoch 1971). The most widely accepted definition is still probably that presented as follows (Figure 1) in the paper of Johnstone and Reid (1981, 207):

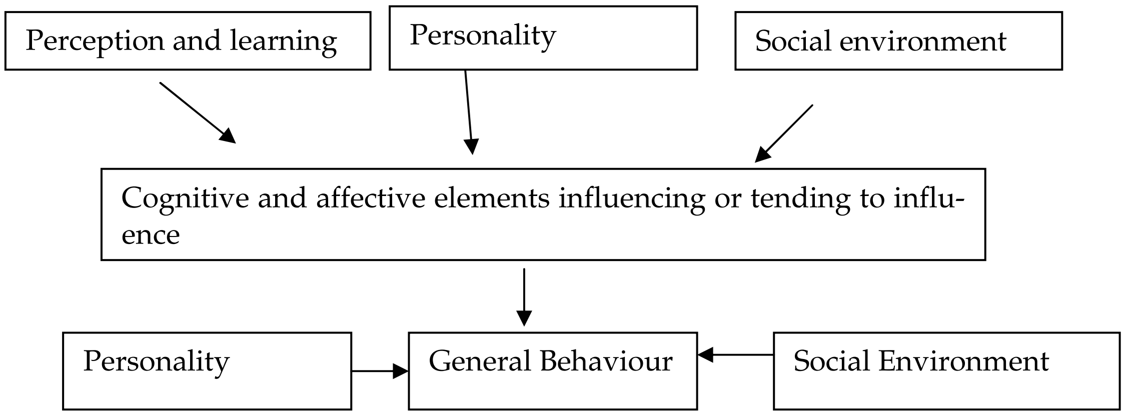


FIGURE 1 Attitude and its components according to Johnstone and Reid (1981)

This picture takes into account the cognitive influences in attitude development (attitude is a state of readiness leading the individual to perceive things and people around him in certain ways), the construct nature of attitudes (attitudes are learned, they develop and they are organised through experience), and the readiness to respond outcomes (attitudes are dynamic). "An attitude is a product of experience, but it enters into subsequent experience as a directive factor" (Allport 1935, 219, cited in Halloran 1967).

Secondly, I will discuss approaches to attitude measurements. According to Kiesler, Collins and Miller (1969) attitudes are almost universally measured by verbal report techniques using pencil and paper. Even though I have used a questionnaire to find out pupils' attitudes on certain environmental issues, it seems sensible to adress the theoretical part of this study to dealing with attitudes and behaviour theories. Many books and papers have been written dealing with the measurements of attitudes. Most definitions of attitudes tell us that attitudes contribute to overt behaviour. It is commonly assumed that attitudes and behaviours are very closely related (ex. Shirgley 1990). In an educational setting, it seems important that any attempts at attitude (or personality) measurements should never be used in a predictive fashion.

The book of Henerson, Morris and Fitz-Gibbon (1987) '*How to measure attitudes'* gives considerable attention to methods of attitude measurement other than the usual self report scales, such as interviews, surveys, questionnaires, using written accounts, such as journals and diaries, observations and sociometric techniques. Major attention is also given to developing one's own attitude measures. Henerson et al. consider the advantages and disadvantages of using different methods in collecting attitude information. They note, for example, that a disadvantage of questionnaires is that they do not provide flexibility of interviews (9). However, they also mention that if one has a variety of concerns, most of which can be covered by asking questions, one should consider using a questionnaire (29). In Suedfeld's (1971) book several writers deal with attitude change, presenting different theories and models. From these theories the motivational theory of attitude change is still the most important proposal offered.

Summers' book (1971) includes many articles written by different writers dealing with attitude measurements, reliability and validity of assessment in attitude measurements, as well as different techniques for construction of attitude scales. According to Thurstone's article (pp.127-141) attitudes can be measured when assuming that attitude scale is used only in situations in which one may reasonably expect people to tell the truth about their convictions or opinions.

2.2 Behaviour and attitudes

The formation of attitudes depends on cognitive, affective or behavioural (experience) input. Not all three elements need to be present in either the input or output. Environmental behaviours such as recycling have been a focus of psychological study for decades. However, in this study I try to concentrate on the literature dealing with the effect of environmental attitudes on students' behaviour and classroom activity: attitudes allow the individual to make sense of the world.

A great number of theories have been developed to explain people's behaviour and action in certain situations. One mark of a successful theory is its longevity. Ajzen and Fishbein (1980a) developed a model for explaining social action and this theory has proved to be very reliable over the years. It has later been improved by adding new variables to it (for example, Ajzen 1991).

Leone, Perugini and Ercolani (1999) have compared three different theories dealing with attitude-behaviour relationships, such as:

1) ***T****heory of* ***r****easoned* ***a****ction (TRA)*, originally presented by Ajzen and Fishbein (1980a) and Fishbein and Ajzen (1975).

2) ***T**heory of **p**lanned **b**ehaviour (TPB)*, originally presented by Ajzen (1985) and Ajzen and Madden (1986) and
3) ***T**heory of **s**elf -**r**egulation (TSR),* presented by Bagozzi (1992).

These theories have been used to predict and understand a specific behaviour. The theoretical models are presented in figure 2 (a-c) (Bagozzi 1992; Leone, Perugini & Ercolani 1999). These theories are very difficult to understand thoroughly and would require many years of committed work. Therefore I am only explaining them shortly because they are tightly linked to my study and those interested can consider them more deeply.

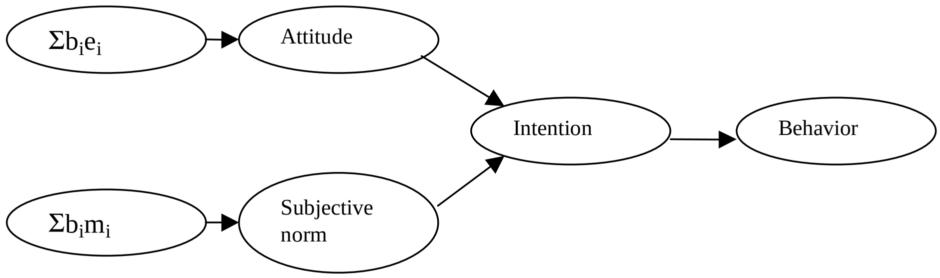
As Ajzen and Fishbein (1980) have pointed out, the main aim of reasoned action theory (TRA) is to predict and understand the causes of behaviour. An outline of the central variables and relationships is presented in figure 2a. This theory hypothesises that behaviour is determined directly by one's intention to perform the behaviour and intention is influenced by attitude (i.e., one's positive or negative evaluation how to behave) and by subjective norm (i.e., the perceived social pressure how to behave). In other words people's intentions - which are the direct predictors of behaviour - are dependent on both individual and social related variables such as attitude toward the act, a personal evaluative response, and subjective norms, the social information available and the perceived social pressure to behave. Both attitudes toward the act and subjective norms are based on cognitive information (Ajzen 1985) and the anticipated consequences of performing or not performing the behaviour affect both attitude and subjective norm. For attitude, beliefs (b_i) that performing the behaviour will lead to certain outcomes combine with evaluations (e_i) of outcomes ($\Sigma b_i\ e_i$). For subjective norm, beliefs (b_i) that specific individuals expect one to perform or not to perform the behaviour combine with one's motivation to comply (m_i) with these specific individuals ($\Sigma b_i\ m_i$) (Bagozzi 1992). According to Ajzen and Fishbein (1980a) the model of TRA is interpreted as a sufficient representation of attitude-behaviour relationships, since all possible external influences on intentions and behaviour are thought to be totally mediated by information processing that underlies attitudes and subjective norms. They assumed that TRA is self-contained and requires no additional variables or relationships for the explanation of behaviour. Even though TRA and TPB theories were later applied widely, especially by those studying physical activity (Smith & Biddle 1999; Hagger, Chatzisarantis & Biddle 2001), these theories were also strongly criticised by many researchers (Bagozzi 1981; Bagozzi & Warshaw 1990), who claimed this theory to be insufficient, including neither the real evidence for a direct path linking attitude and behaviour nor the effect of past behaviour.

Bentler and Speckart (1979) had formally also criticised the original theory of Fishbein and Ajzen (1975), being almost convinced that intentions were directly influenced by previous behaviour rather than attitudes and subjective norms. It is easy to accept their result that previous behaviour has an impact on current intentions and future behavíour and that affect (attitude) has direct and indirect influence on behaviour.

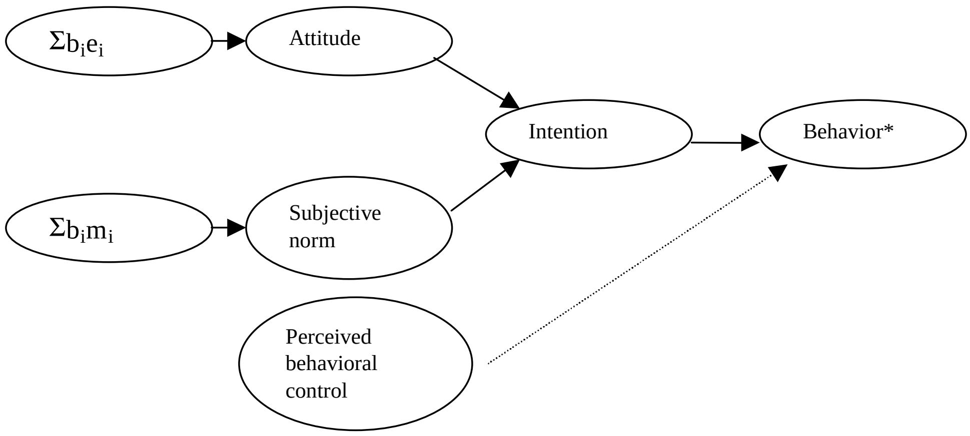
The model of reasoned action theory was later expanded by adding a new variable, ‘**p**erceived **b**ehavioural **c**ontrol’ (PBC), which defined how difficult or easy an action is to perform for a given subject (figure 2b) (Ajzen 1991; Bagozzi 1992). According to this theory of planned behaviour (TPB), perceived behavioural control directly influences both intention and behaviour: the greater the perceived behavioural control, the more positive the behavioural intention and the more likely the performance of behaviour. PBC explains the person’s belief as to how easy or difficult performance of behaviour is likely to be (Ajzen & Madden 1986). However, the direct path from perceived control to behaviour is assumed to exist only if perceived behavioural control is a good representative of actual control. Many other researchers tested later the sufficiency of TPB applied in several different types of research. The study of Terry and O'Leary (1995) proved that separate measures of self-efficiency and perceived behavioural control should be included in the theory of planned behaviour.

In his critique on these theories, Bagozzi (1992) claimed in his theory of self-regulation (TSR) that the main omitted factor is desire and the influence of attitudes is mediated by that**.** A desire implies a motivational commitment to act, whereas an attitude does not. An attitude provides a reason for forming an intention to act according to one’s intentions that are believed to lead to valued outcomes. The TSR retains the effects of subjective norms on intentions and the effect of intentions on behaviour. It is easy to accept that the intention is closely linked to a desire and it is easy to agree with Bagozzi (1992) that intention implies desire, but desire does not necessarily imply intention. For example, an intention to solve a given laboratory problem is closely linked to a desire to do so, whereas one can have a great desire to throw the residue from the experiment into the sink without necessarily any implied intention to behave according to this desire. The means necessary for carrying out a particular behaviour are always intended but not always desired. Intending is more closely connected to action than desiring and intentions have an important role in behaviour predictions. Intention can also be partly explained by past behaviour (Bagozzi 1992).

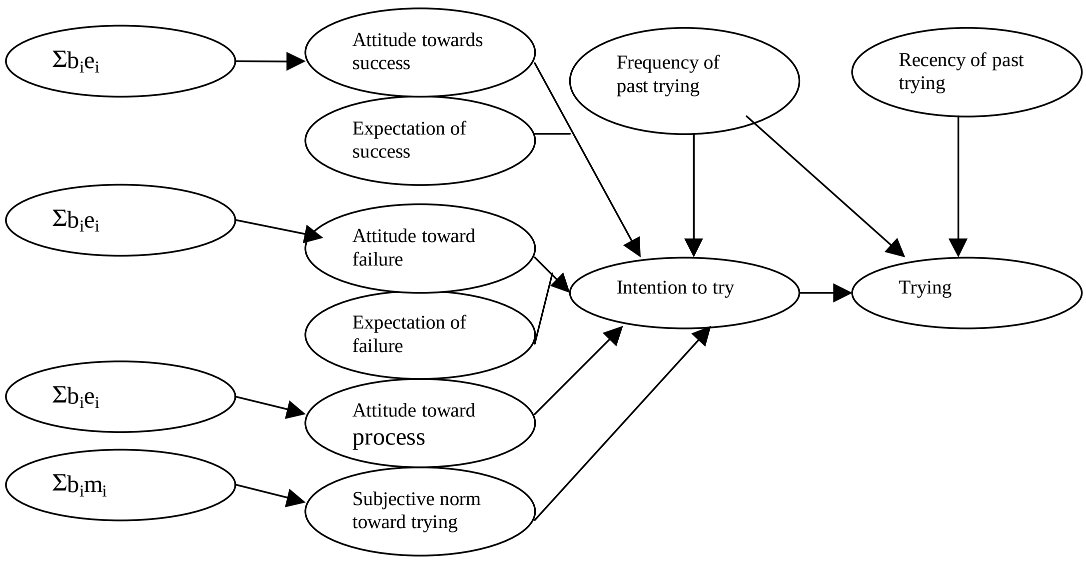
In his paper Bagozzi (1992) has explained the *theory of trying* (figure 2c), originally presented by Bagozzi and Warshaw (1990). It is based on the hypothesis that behaviours consist of intended actions and unintended action. An intended action requires that an actor has a reason for acting in a certain way based, for example, on his attitude or subjective norms and belief that he can initiate the steps needed for action. In contrast to that, an unintended action is a movement or response - typically arising from, for example, habit, impulse or reflex - not based on reason and not planned or intended. Expressed in simple terms, the theory of trying attempts to explain the behavioural striving toward goals.



a. Theory of reasoned action



b. Theory of planned behavior



c. Theory of trying

FIGURE 2 The Theory of Reasoned Action presented by Bagozzi (1992)

Bagozzi (1992) has studied the differences between the theory of trying and theories of reasoned action and planned behaviour. Intentions are found to lead to volitional behaviours in the theory of reasoned action, to non-volitional behaviours in the theory of planned behaviour, and to strivings in the theory of trying. One problem common to all these theories is that none of these theories (TRA, TPB or Theory of Trying) explains the relations between attitudes, intentions and action. In his critique Bagozzi mentions that common to all these theories is that the processes explaining how intentions produce action as well as how outcomes are produced are left unexplored. According to him, to discover an important class of actions and outcomes when attitude theory needs refinement, it is useful to consider three species of intentions: *present oriented* and *future oriented* - which apply to actions proper, and *goal-directed* - which addresses outcomes toward which one strives.

- *A present-oriented intention* is a personal decision to act immediately. Unless an unlikely event of sufficient magnitude arises straightaway, the present-oriented intention will lead to action.
- *A future-oriented intention* is a decision to act later. Bagozzi explains two cases that are of interest for the present study. First, under a non-contingent future-oriented intention, one decides at t_1 to act at t_2 (t_1 and t_2 are different moments of time).

It is obvious that if the gap in time between t_1 and t_2 widens, the chances will increase that one will change one's intention or some unexpected event can make pupils' intention impracticable or undesirable. Second, under a contingent future-oriented intention the decision maker again decides at t_1 to act at t_2. Unlike t_2 in a non-contingent case, this t_2 is an unknown future time.

- *A goal-directed intention* is a decision to pursue a goal or produce an outcome. An outcome is an end state that one attempts to produce. After a person forms an intention to pursue a goal, the question arises how to reach the goal and various plans are formulated. According to Bagozzi, the intention-behaviour relationship, particularly for goal directed behaviours, is predicated on decisions with regard to means, instrumental acts, motivation, and conditions peculiar to the actor (e.g., abilities, liabilities) or the situation.

Recent theories are *the **M**odel of **g**oal-directed **b**ehaviour (MGB)* and *the **E**xtended **m**odel of **g**oal-directed **b**ehaviour* (EMGB) (Perugini & Conner 2000; Perugini & Bagozzi 2001). These models are presented in Figures 3a and 3b. The EMGB emphasizes the importance of variables by including desire for a goal and goal perceived feasibility alongside positive and negative anticipated emotions.

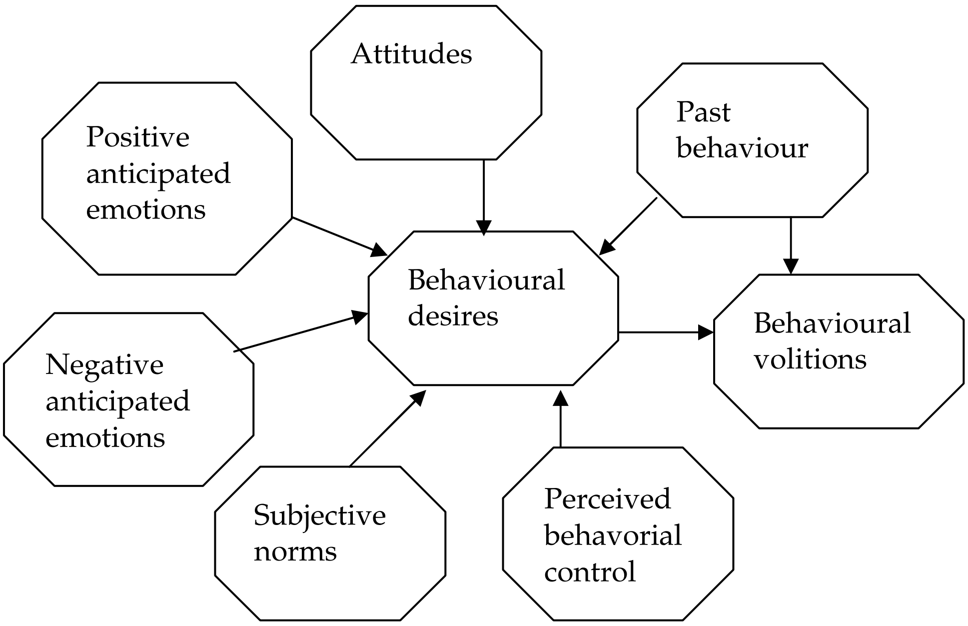


FIGURE 3a The model of goal-directed behaviour (MGB) (Perugini & Conner 2000, 707)

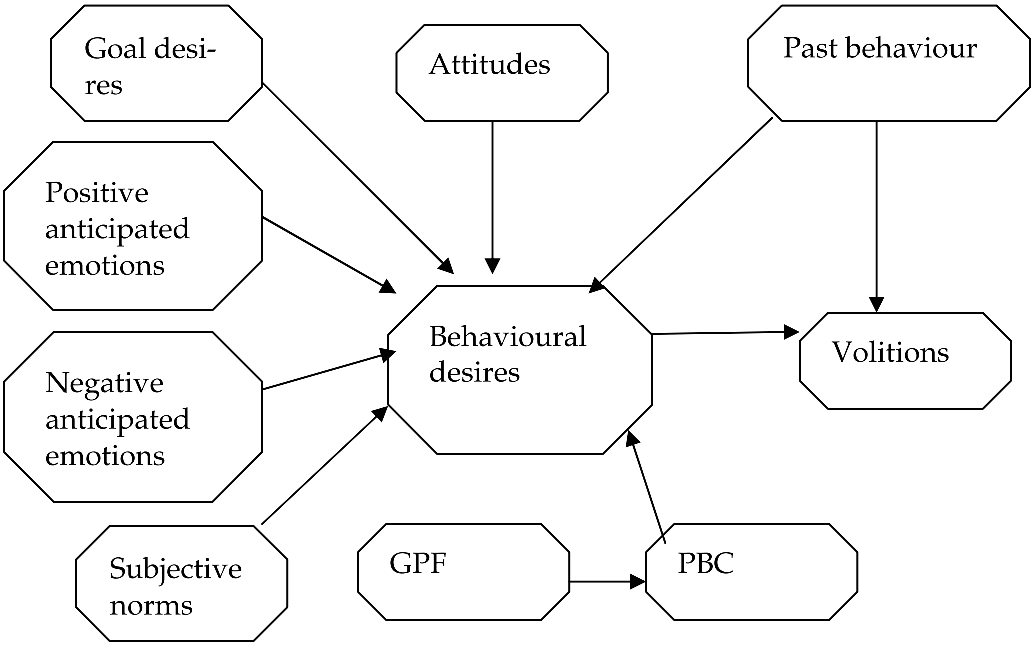


FIGURE 3b The test of the extended model of goal directed behaviour (EMGB). GBF = **G**oal **p**erceived **f**easibility, PBC = **P**erceived **behaviour**al **c**ontrol. (Perugini & Conner 2000, 721).

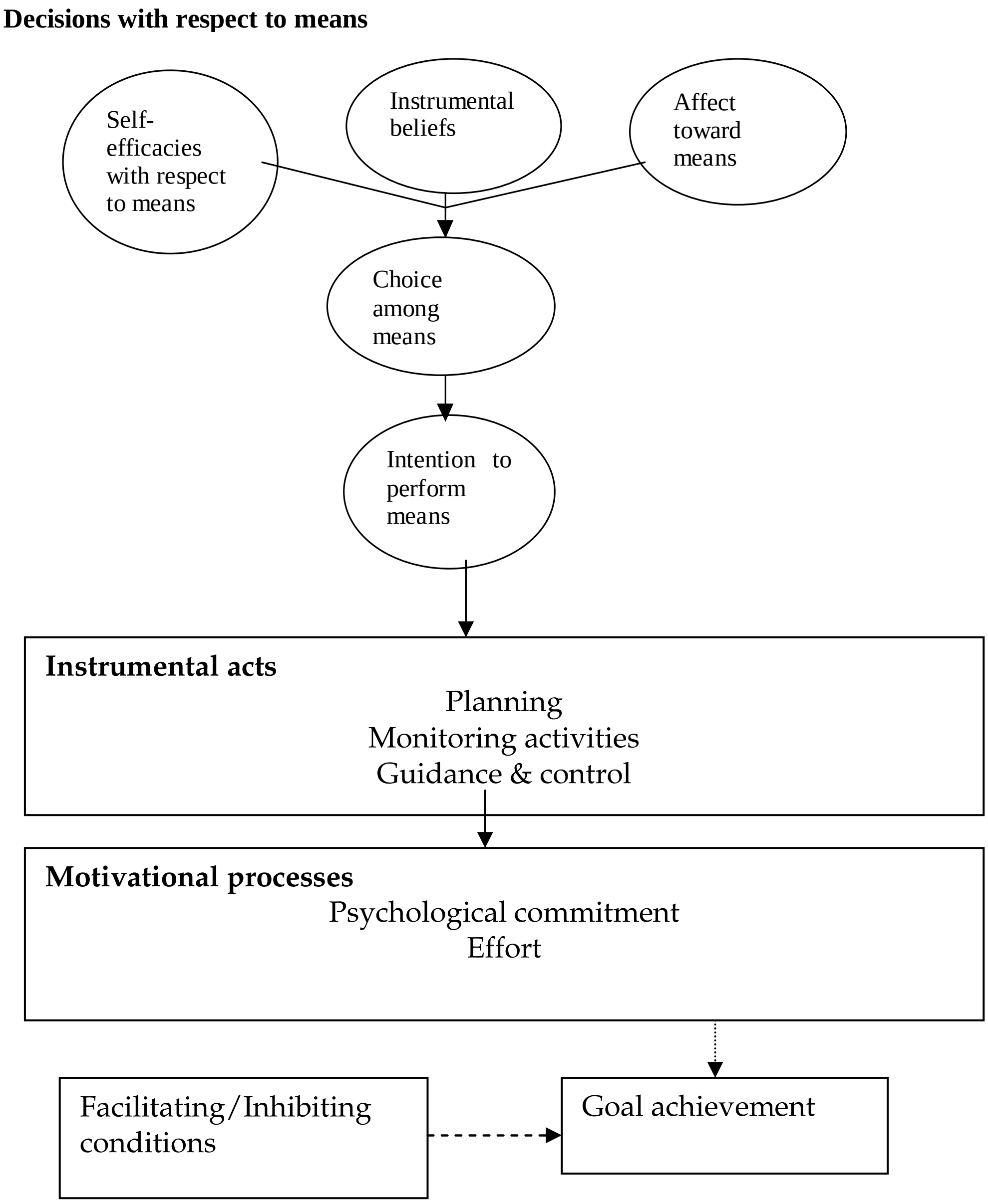


FIGURE 4 Volitional model of goal directed behaviour

The model of goal directed behaviour (MGB) presented in figure 4 actually extends the theory of planned behaviour (TPB) presented earlier (figure 2b).

While, according to TPB, behavioural intentions are determined by attitudes toward the action, subjective norms, and perceived behavioural control, the MGB focuses additionally on affect, motivation, and habit. Past behaviour is introduced in the MGB as a proxy of habit that has been formally reported in many studies as having independent effects on intentions but only just recently its influence on current behaviour has been accepted. Aarts and Dijksterhuis (2000) define habits as a form of goal-directed automatic behaviour, which is activated automatically by the presence of relevant environmental cues, provided that the relevant goal is activated. According to studies of Perugini and Conner (2000) as well as of Perugini and Bagozzi (2001), in the MGB past behaviour is hypothesised to have a direct impact on behaviour but, depending on circumstances, also on desires and intentions (see figure 4). In the MGB the target behaviour is instrumental to goal achievement and desire is relative to given behaviour because it is conducive to goal attainment and to some extent knowledge or the effects.

Because attitude is defined as the amount of feelings or affects on or against something, my questionnaire made use of a scale from 1-5 (*I have exactly the same opinion - I have a totally different opinion*) with some exceptions. This way I allowed the students to express their opinion, the extent to which they agreed or disagreed with the statement. In my study some of the attitude statements refer directly to behaviour. In such cases the scale used is 1 *always* and 5 *seldom.* I assume that a pupil's attitude towards some object is derived from the coming together of beliefs and/or feelings in some logical consistent way.

2.2.1 Environmental education and attitudes

Today when talking about environment, we usually mean: natural environment, cultural environment or built environment and social environment. (Kiiskinen 2001, 65). The concept of virtual environment is also known to people of today. In this study the concept environment refers to natural environment.

There has been and still are many different conceptions of what environmental education is. Åhlberg (1998, 6) defines it as an education which tries to promote understanding, values and skills and all other kinds of learning about environmental problems and how to deal with them or remove them totally. This is how it is also understood in the present research. Environmental education in this study, as stated by Miller (1998) and cited by Åhlberg, concerns most of all learning about environmental problems, why they are problems, how they are caused, how they could be solved, and learning the skills needed to help in solving them. Also, as stated by Bush, Morratt and Dunn (2002), the environment is often conceptualised negatively as including a series of problems.

An interesting feature is that the title of Lob's book (1997), *20 Jahre Umweltbildung in Deutchland - eine Bilanz*, implies that environmental education has been familiar in Germany for more than 25 years. Environmental education today in Germany as well as in Finland is included in the school curriculum, but it depends on the teachers of different subjects how much they really deal with it. In Finland as well as in Germany environmental education is traditionally mainly included in biology. However, in Finland, according to the study of Eloranta (1995, 185-209), environmental issues are also included in several other school subjects. Her study showed that teachers of Finnish language, history and social science, biology and geography, physics and chemistry, as well as home economics include environmental issues in their teaching. The main general issues that all teachers talked about were pollution, recycling and living environment (either natural or built). In addition to these, oil disasters, air and water pollution, harmful substances, the ozone hole were mentioned by most of the teachers.

The main focus of environmental education programs has been to change environmental behaviour through increasing environmental knowledge. The main goal of environmental education is to assess environmental issues, find and offer long-term solutions to different environmental problems and create pre-environmentally conscious behaviour. The everyday scientific construction of environmental attitudes consists of attitudes concerning environment, knowledge of environment and information on environment that we get through mass media.

Since one of the most important determinants of behaviour is knowledge (Ramsey & Rickson 1976) all individuals should be given more environmental information and knowledge in order to be able to change their environmental attitudes and behaviour. As noted by Ramsey and Rickson (1976, 16), "knowledge of ecological concepts seems to lead to positive attitudes toward pollution abatement measures more than to passionate interest in unqualified pollution control." According to Arcury and Christianson (1990), increasing the general environmental knowledge of the public is still rather slow. It seems that even though over ten years have passed since their publication it is still the case. It is also known that giving environmental knowledge on environmental issues does not necessarily foster positive environmental attitudes. Iozzi (1989) has pointed out that an individual's response to the environment is based on three domains: affective, cognitive, and behavioural. However, most environmental programs have paid little attention to the importance of other information sources than cognition. In their study Millar and Millar (1996) have pointed out that attitudes formed through direct experience (affect based) are better predictors of behaviour than those attitudes formed on indirect experience (cognitively based).

Because a clear goal of environmental education - as mentioned earlier - is to change behaviour, it is essential to understand the basis of environmental attitudes in order to facilitate changing environmental behaviour. Bryant and Hungerford (1977) showed in their study that young people's attitudes toward the environment start to develop at a very early stage: children acquire knowledge and develop attitudes about environmental issues already in kindergarten. Because early attitudes and knowledge shape later thinking and because attitudes do not change easily, there will always be a great need to assess the developing of environmental attitude and knowledge during childhood. It is also known that by the time young people reach adolescence they have already acquired sufficient level of understanding of environmental issues, such as ecology, sustainable development, economics and technology, for example, to be able to formulate their own views on these issues (Iozzi 1989).

Bryant and Hungerford (1977) detailed the construction and preliminary validation of the **C**hildren's **E**nvironmental **A**ttitude and **K**nowledge **S**cale (CHEAKS). The CHEAKS development was guided by the Maloney and Ward (1975) ecology scale, which was reviewed positively by Gray and others (1985), according to Leeming and Dwyer (1995). Additionally, the scale was reviewed by educators and a panel of ecology and test construction experts. The scale's development was systematic and representatively sampled the relevant content domains, as guided by the literature and expert opinions.

2.2.2 Environmental attitude-behaviour correspondence

Many researchers have proposed that attitudes may not necessarily predict behaviour (Ajzen & Fishbein 1980b; Shetzer, Stackman & Moore 1991; Scott & Willits 1994). Cook and Selltiz (1964) appreciated that attitudes, on their own, do not control behaviour. The reason may be lack of congruence or specificity between the attitudinal and behavioural measures or it can also be reliance on a "poor quality attitude measure" (Weigel 1983, 262) or failure to recognise the influence of external factors on behavioural prediction (Fishbein & Ajzen 1975). According to the study of Kahle and Berman (1979) there are four possible relationships between attitudes and behaviours: (1) they are unrelated (Wicker 1969), (2) behaviours cause attitudes (Bem 1972), (3) attitudes cause behaviours (McGuire 1976) or (4) reciprocal causation exist between them (Kelman 1974). A fifth alternative, which is little considered, is that both are produced by some third phenomenon (McBroom & Reed 1992).

However, if attitudes are causes of behaviours, then the knowledge of attitudes allows prediction of behaviour, and also changing attitude allows one to change or control behaviour, even though earlier researchers Cook and Selltiz (1964) appreciated that attitudes, on their own, do not control behaviour. Similar results were recorded thirty years later by Bratt (1999b), who concluded that norms and assumed consequences do not influence environmental behaviour.

2.2.3 Attitude development through interaction in a school context

There seems to be no doubt that attitudes play important roles in learning (Shaughnessy et al. 1983; Parkinson et al. 1998). However, the various theories of attitude change are so diverse that it is extremely difficult to get a unified picture. Many of the theoretical positions derive from fairly specific experimental designs, and may not be applicable to different situations. Textbooks and equipment resources as well as teacher training have, within sciences, been concentrated on cognitive objectives. Attitudinal objectives, however, have been largely ignored but have recently started to receive more attention. Khan and Weiss (1973) have criticised the neglect of attitudes and argued that affective outcomes are too important to be left to chance.

Since the behavioural-learning theorists suggest that attitudes can be "learned", it means that attitudes have varying degrees of cognitive content, and this content may be accessible through various learning situations. Many studies have examined the development of attitudes in a school context (Goodwin et al. 1981; Kelly 1986; Morrell & Lederman 1998). The paper by Goodwin and others examined pupils' attitudes to school, science and science lessons and their performance in science within the age group from ten to thirteen years in Manchester. Their study covered approximately 8000 pupils together. They reported that pupils' attitudes toward school, science and science lessons were as important as their ability to cope with the subject at school and they made an attempt to monitor through questionnaires changes in these areas during the period of their study. They were aware that the instruments developed to measure changes were not very good and therefore they were very cautious in interpreting the results. According to their study pupils had a positive attitude to both school and science at the primary stage and less positive in the first year of secondary school although still positive. They found out that the mean result on the attitude to science questionnaire increases slightly but not significantly at this stage of the project. It is noticeable that at the end of the first two years at secondary school, pupils had a less positive attitude to both school and science than at primary school or in their first secondary year. An interesting result in their study was that girls seemed to have significantly higher scores with regard to attitudes to school, but boys have a higher mean attitude to science score than girls in each stage. However, they also found that the difference between boys and girls was statistically significant at the primary school stage when girls' attitude was growing and boys' attitude was slowly decreasing. An interesting finding was that at both secondary stages the mean attitude to science lessons scores of the boys and girls were very close and showed no significant differences.

In recent years the development of favourable attitudes towards science is being recognised as an important aspect of science education. Attitudes play an important role in learning together with learning environmental variables and the teacher (Shaughnessy et al. 1983). As we know, older children often like science less than younger children. This was also the result of Kelly's study (1986, 407), which stated "most children's attitudes to science decline between ages 11 and 14." Her study was done in England at a time when all pupils studied science at school. A teacher's attitude on a particular point may have the most enormous effect on the pupils, especially if the pupils' attitudes towards the teacher are strong, either positive or negative. The question Kelly was asking in her study was "why are some schools more successful than others in maintaining or even improving children's positive initial attitudes in science." Three years later Schibeci (1989) also studied the connection of home, school and peer group influence on students' attitudes and achievement in science. Martin (1996) found in his studies that teachers who had the greatest positive effect upon students' attitudes and achievement in science were those most experienced in scientific training and with a great interest in science. According to Reynolds and Walberg (1992), science achievement influences science attitudes and not the reverse.

Reid demonstrated in his PhD study that attitude development was stable with time. (Reid 1978). He also showed that development in the area of attitudes of social awareness related to science, age and normal teaching had little or no direct effect on attitude. His studies were based on 14-to-16 year-old science-oriented pupils. Later Johnstone and Reid (1981) presented in their study a model for attitude change based on the earlier findings of several researchers. Attitude change normally occurs in small steps and development of attitudes is a cumulative process that happens through many small steps. There seem to be attitudes that may change easily and attitudes that change with great difficulty or not at all. Even though our previously held attitudes are not easily affected, Johnstone and Read were convinced, based on their model, that it seems possible to persuade the person, for example, that his attitude to pollution is based on inadequate evidence, and should be modified. In his study Reid (1978) came to the conclusion that when cognitively oriented attitudes change, the changes seem to be stable with time. Even though Cook and Selltiz (1964) stated that attitudes, on their own, do not control behaviour they no doubt have a great effect on that.

2.2.4 Environmental attitude and knowledge in the chemistry laboratory

Several research findings point out that pupils' positive attitude towards and knowledge of environmental issues is higher if they engaged in some environment activities, even with only two weeks' participation (Crater & Megs 1981; Aird & Tomera 1977). Therefore it seems very important to encourage pupils' participation in environmental activities if we want to improve their environmental attitudes and knowledge. The more experience they have of environmental issues, the more easily the positive attitudes develop.

It is known that ecological knowledge affects environmental behaviour directly as well as indirectly - through environmental awareness (Dickmann & Preisendorfer 1998). According to Eloranta (1995, 185-209), Finnish science teachers in the lower and upper secondary level teach environmental issues whenever they think it is well integrated in their own subject area. Teaching environmental issues is mainly the responsibility of teachers of biology and geography, physics and chemistry. Physics and chemistry teachers concentrate on teaching mainly environmental problems, acid rain and energy and its environmental effects as well as air and water pollution, ozone layer, recycling, greenhouse effect, corrosion, and littering. Special integrated project weeks or days is the common way to teach environmental issues in Finnish schools. However, a systematic program in the area of environmental education is still missing in spite of numerous studies and study plans constructed by many Finnish researchers (Heinonen & Kuisma 1994; Käpylä 1994; Åhlberg 1998: Helve 2001; Anon 2001).

According to findings of Leeming and Porter (1997), it seems obvious that we should pay attention particularly to young children when thinking about environmental attitude and knowledge because, as they point out on the baseis of their study, young children

a) are less likely to have well-established environmentally harmful behaviours to "unlearn"
b) have a longer period to influence environmental quality, and
c) may serve as effective agents to promote environmentally responsible behaviour in others.

Also the study of Kari (1980) supports these findings that young pupils are interested in their own environment and their attitudes can still be affected by teaching methods.

However, some other researchers have not found significant differences between the age groups from third to eighth grade (Armstrong & Impara 1991). Without doubt research proves (Cukrowska et al. 1999) that positive attitudes have an enormous effect on chemistry learning and, through this, on learning of environmental issues. Cukrowska was convinced that pupils' positive perceptions towards chemistry are a major factor in their success and attitudes seem to be highly influenced by their background. When Wong and Frazer (1996) studied the effects of science laboratory classroom environment on students' attitudes towards chemistry in an Asian country, they used 35 items with five different scales: "student cohesiveness", "open endedness", "integration", "rule clarity" and "material environment". A five-point scale, with the alternatives of "almost never", "seldom", "sometimes", "often", and "very often", was used for responses. Interesting in their results was that students seemed to show less appreciation to open-ended experiments and greater co-operation among students. They concluded that this implies that students' attitudes towards chemistry are likely to be enhanced in chemistry laboratory classes where laboratory activities are linked with the theory learned in non-laboratory classes and where clear rules are provided. These research findings also support the teaching of environmental issues by other than chemistry teachers, although the results may not be generalizable across cultures and grade levels.

2.2.5 Environmental concern

Research on environmental concern is extensive and studies have identified factors that determine environmental behaviour. Often these factors are related to specific behaviours such as recycling that have been thoroughly examined (e.g. Simmons & Widmar 1990; Hopper & Nielsen 1991; Lansana 1992; Porter & Leeming 1995). Most environmental studies have employed quantitative approaches and some studies have identified a number of factors that determine environmental behaviour. Hines, Hungerford, and Tomera (1986) found the following variables associated with responsible behaviour: Knowledge of issues, knowledge of action strategies, attitudes, verbal commitment, and sense of personal responsibility. Their research concentrates especially on young people's environmental concerns.

Tanskanen (1997, 20-24) has examined environmental concern of Finnish people from an international perspective. According to him the main concerns of people in the EU countries in 1992 were: 1) global problems such as depletion of the ozone layer and global warming, 2) national problems such as nuclear power and industry with their waste problems, pollution of lakes and streams, and air pollution, 3) local problems such as garbage disposal and air pollution. His study showed that German people are much more worried about both global and national problems than Finnish people and slightly more worried about local problems also. As presented in his study German people seem to be more worried about each of these problems than Finnish people.

In order to be able to develop the strategies for responsible environmental behaviour, we need to understand how peoples' environmental behaviour can be influenced. Possible social pressure as well as children's influence on peoples behaviour is known from several studies (Bratt 1999a,b). Also the assumed consequences of behaviour can influence peoples' behaviour. Some researchers have reported that junior high school and high school students who attended special environmental courses expressed an increased responsible behaviour and awareness of environmental issues (Jaus 1984; Ramsey 1993). Waterworth and Waterworth (2000) call this knowledge-based behaviour and separate it from rule-based behaviour as well as from skill-based behaviour. They explain the differences between these behaviours by suggesting that skill-behaviour takes place at a more or less unconscious level whereas knowledge-based behaviour happens at a conscious level as does rule-based behaviour. Their study is supported by the study of Lyons and Breakwell (1994), who were convinced by their own study that perhaps there are differential levels of concern for different environmental issues. They thought that this may reflect differential levels of knowledge about certain environmental issues but advised caution in interpreting this, mainly because their measures of environmental knowledge were self-reported.

Hallin (1995) tried in his study to explore motives for different kinds of environmental actions and identify major factors that cause or prevent behaviour change. His study mainly concentrated on young conservers. The first group that Hallin identified in his study were those who had inherited their parents' value systems, so their conserving behaviour was not a result of their own experiences but they were raised to be conservative. Some of them did not relate their conserving behaviour to environmental problems. A second group that Hallin identified consisted of those whose value system changed over a long period of time because of some events. A third group of conservers were those who changed their behaviour because of their occupational status and a fourth group comprised of those who could not exactly tell why they changed their behaviour. In many cases spouses, for example, were more environmentally concerned and gradually caused the behaviour change. All these different reasons for behavioural change indicate the difficulties to be faced in trying to identify the factors that determine environmental behaviour.

It is easy to agree with Diekmann and Preisendorfer (1998, 79), who wrote that "despite a high degree of environmental consciousness, behaviour seems to follow traditional lines of action, and every day experience points to obvious inconsistencies between verbal claims and actual behaviour." People use cars or airplanes for their vacation trip, do not have catalytic converters on their cars, do not use public transportation even they could, do not reduce warm water consumption in their household, do not turn down their heating system when they leave their apartment for a longer period and do have a clothes-drier in their household. This list could be continued very much longer. Nearly half of the respondents in their study agreed that they couldn't contribute much to improving environmental quality by their own behaviour. According to Geller (1995, 194), "it is critical to establish the situations and contingencies that increase readiness to actively care." People need to increase their willingness to actively care in their environment in order to emit altruistic behaviour for environmental protection. Self-esteem, belongingness, self-efficacy, personal control and optimism are the factors that usually influence care actively. In Finland women seem to be more pessimistic when environmental issues are concerned than men (Anon 2001). A larger proportion of women than of men think that economic growth will destroy nature little by little.

Age has been found to be inversely related to positive environmental attitudes. Older people tend to be less concerned about the environment than younger people (Arcury 1990; Van Liere & Dunlap 1981). The relationship between gender and environmental concern seems to be conflicting. Some studies have proved that women are more concerned about the environment than men (Kuhn 1979; Van Liere & Dunlap 1981; Diekmann & Preisendorfer 1998) and others have showed that men have a more positive attitude toward the environment than women (Arcury & Cristianson 1990). Maybe that is due to the research finding of Bourassa (1990), who proved that men have a higher concrete knowledge - which could not be explained, however, by higher levels of education - about environmental problems than women. On the other hand, several studies showed no differences between sexes (Blum 1987; Roth & Perez 1989). Similar results were also obtained in the late sixties by De Groot (1967), who, according to Tognacci and others (1972), after reviewing six early studies of public attitudes toward air pollution concluded that age and gender were poor predictors of concern. Still, according to some studies, differences between the two sexes were dependent on the specific issue concerned (Schahn & Holzer 1990). It seems in the light of research that generally urban people have more positive environmental attitudes than rural people and that more educated people are more environmentally concerned than less educated (Ramsey & Rickson 1976; Tognacci et al. 1972; Blum 1987; Anon 2001).

Together with consumers' growing environmental concern, efforts to improve measures have been developed since the 1970s. Despite improvements in the measurement of environmental concern, problems remain. Van Liere and Dunlap (1981) tried to find an answer to the question: does it make a difference how environmental concern is measured? According to them, environmental concern measures can be based on different substantive issues (such as, for example, pollution or natural resources) or different types of theoretical conceptualisations (such as a Likert-type attitude scale and frequency-of-behaviour scale) or both.

Van Liere & Dunlap (1981) have presented a model (figure 5) that shows the relationship between a sociodemographic characteristic (e.g. age, sex, etc.) and environmental concern. Van Liere and Dunlap (1981, 655) assumed that a sociodemographic variable (for example, age) was measured once and environmental concern was measured more than once. According to them, "the environmental concern measures (Y_j's) could be based on different substantive issues (such as pollution, population and wildlife scales) or different theoretical conceptualizations (such as a Likert-type attitude scale and a frequency-of- behaviour scale), or both". Based on their model all of the environmental measures are influenced by environmental concern. They hypothesized that the different environmental concern measures will be highly inter-correlated (a's and b's in figure 5). Their research proved that cognitive measures dealing with pollution and natural resources are the most consistent indicators of environmental concern.

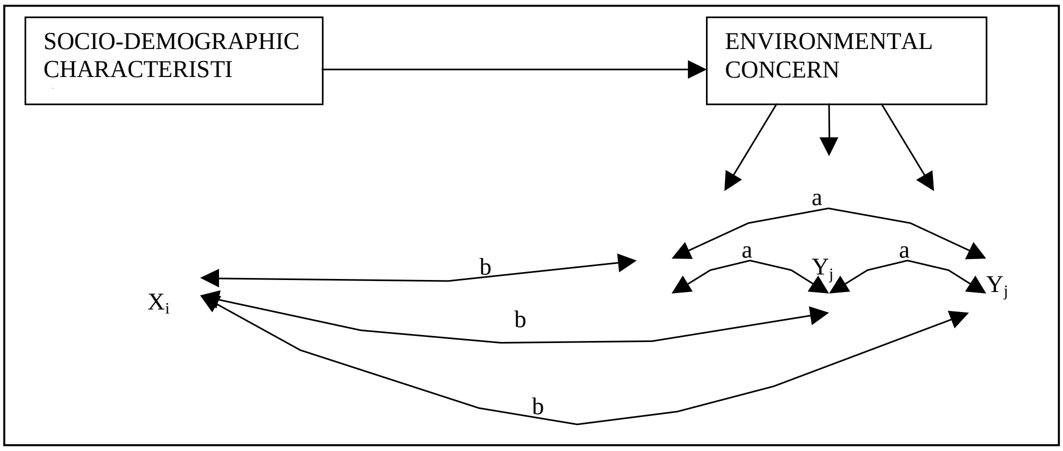


FIGURE 5 Model illustrating two types of consistency, where X_i refers to sociodemographic measure (i = age, gender, etc.) and Y_j (j = population attitudes, conservation behaviour, etc.) refers to environmental concern measures based on differing substantive issues or theoretical conceptualisations or both (Van Liere & Dunlap 1981)

In terms of consistency among different substantive issues, Van Liere and Dunlap found concern about population issues to be rather distinct from concern about natural resources and pollution, while they also found the latter two to be strongly inter-correlated. Similarly they also found when studying Likert-type attitudinal items that behavioural measures were not strongly inter-correlated. This model can be applied directly to this study (i= age, gender, Finnish sample, German sample) and (j= students behaviour in the laboratory, self-reported behaviour).

2.3 Environmental values, actions and responsibility

The future of humankind is critically dependent on the proper management of the environment and its resources: today's environmental problems arise from the lifestyles humans lead. Although it is known, based on previous chapters, that awareness and knowledge will lead to behaviour change, it is also known that people’s behaviour is rather complex. As Borden and Schettino (1979) noted in their study, the relationship between behaviour and knowledge and the extent of feeling toward the protection of the environment is close to zero. At the end of the twentieth century Burger and others (1998) studied people's willingness to use federal funds to solve some environmental problems, such as making drinking water safe, preserving rainforests, and removing trash from the oceans. They found out that women were much more willing to spend funds on solving these problems than men and they also rank the severity of problems higher than men. It means that women are more concerned about the environment.

As mentioned earlier, recycling is one of the first actions that people started in their concern for their environment. Reams and Geaghan (1996) studied if a special recycling program had an effect on litter. They found out that it increased people's ability to recycle and, because in this program no price was paid to collectors, it can be deduced that it was because people's attitude was favourable to recycling. They concluded that the program appealed to participants' pro-environmental values. The earliest and most prominent strategies for increasing, for example, recycling strategies have been reward-based. Providing a reward in the form of prizes or money has been used in many experiments and has been consistently found to promote recycling. At the end of the 70s, Hamad, Cooper, and Semb (1977) found that a reward was more effective than verbal information in increasing newspaper recycling among primary pupils. At the same time several researchers evaluated the use of different types of lotteries to increase recycling. A lottery was found to be a very successful technique for increasing the amount of paper recycled by college students by at least 80% (Geller, Chaffee & Ingram 1975) in the late 70s and 13 % in the early 90s (Diamond & Loewy 1991). The reward seemed to work to a certain point in increasing recycling. Lotteries produced more participation in recycling programs and this way increased recycling among normal households. However, as unexpected as it sounds, Coach, Garber, and Karpus (1978-1979) found at the end of the 1970s an interesting result whereby increasing the amount of paper necessary to receive the prize had very little effect on recycling behaviour of college students. The later results of Needleman and Geller (1992) among employees proved that the reward contingency was found to lead to greater participation and greater quantity as well. However, what causes anxiety today is that the amount of employees willing to commit to the recycling project was generally low. Unfortunately the authors did not report any extended follow-up data.

Some recycling strategies used have also been penalty based. Levitt and Leventhal (1986) studied New York’s so-called “bottle law” which required people to pay a deposit on returnable bottles and cans. Consumers who did not return containers were penalised by higher costs. In the beginning people did return more containers, but over one year the amount of returnable containers diminished.

Likewise De Young (1996) based on several earlier research studies, notes that there are three themes in the research on promoting conservation behaviour. These are classified as being concerned for the environment, the biosphere itself, for the welfare of others, and for what benefits concern for the environment can provide for oneself. In their article "Encouraging pro-environmental behaviour: the environmental court as contingency manager"

Potter and Dwyer (1995) present a case history of how people can be enforced to control the environmental problems in an urban setting. Both penalty and reward strategies have been used throughout time.

3 ENVIRONMENTAL KNOWLEDGE, BELIEFS AND ATTITUDES

Learners' environmental knowledge, as it is understood in this study, consists of their factual knowledge about environmental phenomena, understanding and misunderstanding of the phenomena, and sources of learners' environmental information. This study examines students' environmental knowledge by focusing on certain environmental issues and their familiarity to students involved and learners' information sources.

It is assumed that scientific knowledge may increase awareness of implications of scientific developments for the environment and the problems it may cause. Also it increases people's knowledge of the limits of science and technology in providing solutions to these problems. The more people know, the more they will be interested in and concerned about their environment (Durant et al. 1989). Science-based knowledge of environmental issues, according to Rickinson (2001), develops through informal sources such as personal observations and media.

In their article (1996, 91) Prelle and Solomon wrote that "often in educational literature the link between the kind of environmental knowledge which education may impact and the outcome in terms of responsible action has been assumed to be linear in far too simplistic sense." However, it is known that the connection between environmental education and behaviour is not so simple. Prelle and Solomon found that even though many pupils in England and Germany may be active in environmental causes or may express their approval for those who are, this does not mean that they have any plans to solve environmental problems. Activity to act in certain situations varies from person to person as well as from one topic to another.

Blum (1987) refers in his study in Eyers (1975) research dealing with sources of information that students acquire their environmental information. Eyers had asked students to indicate through which of the four sources of information they had gained most of their knowledge of the environment: 1) at school in some courses, 2) at school in special environmental course 3) private reading and mass media, or 4) talking with their parents. Blum studied information sources that ninth- and tenth-grade students use in obtaining environmental information through five surveys conducted in the United States, Australia, England, and Israel. In this research Blum separated private reading from television and radio and also divided information gained at school into biology and other school subjects. The main information sources that students acquire their environmental knowledge in all these countries were, according to Blum's study, mass media (radio and television) and the press. Next most important was education in school (either through general school subjects or biology). Special environmental courses were seldom taught in schools in Australia or England and therefore parents, friends and other people were more important information sources than any special school courses. Blum's data clearly proved that most of students' environmental knowledge originates from outside schools. The seriousness of various environmental problems was ranked lower than road accidents, crime and vandalism. Following these were air pollution, pollution (in general), and water pollution. Because the students participating in Blum's study did not have any special environmental course as a source of their environmental knowledge at school, their answers were also not what educators would have expected. In all countries boys achieved higher marks on knowledge items (knowledge of facts and knowledge of concepts) as well as on a general achievement test than girls.

Blum (1987) also found some significant differences between schools in students' achievement on knowledge and belief questions. Beliefs, as understood in this research, are closely related to attitudes. Beliefs refer to the information (the knowledge) a person has about an issue in question. Blum wrote that "students' beliefs tended to be stronger than their factual and conceptual knowledge."

Googh (1995) studied environmental values and beliefs of people in Estonia, Latvia and Sweden. According to him, a person's beliefs can be classified into primitive and primary beliefs. Primitive beliefs are that humankind is above and apart from nature, which should be utilised by humans. According to primary beliefs, progress and growth are natural, inevitable, and good. General environmental concern together with these primitive beliefs are primary beliefs. Googh used a five-step scale (very serious, serious, don't know, not so serious, and not at all serious) when measuring concern for local environmental problems. He used the following items: *Water pollution from towns and factories, water pollution from farmlands, industrial waste, household waste, air pollution from industries* and *air pollution from transport*. The importance of primary beliefs in a person's belief hierarchy has earlier been stressed also by Fishbein and Ajzen (1975).

Prelle and Solomon (1996, 94) used nine environmental issues in their study of young people's approach to environmental issues in order to find out students' environmental attitude and knowledge: *packaging and litter, acid rain, the hole in the ozone layer, the threat to wildlife, cutting down the rain forest, the use of private cars and public transport, nuclear power stations, farming and our food* and *the pollution of rivers and beaches*. First the students were asked to tick one of the two boxes labelled *very important* or *not so important* for each of these issues and after that they had to mark the most important three issues with a star. Then for these three "starred" issues students were asked to answer the questions: "Why do you think it is important?", "What do you think should be done about it?" and "What do you yourself do about it?" Both German and English students were in agreement about the three most important issues: *the hole in the ozone layer*, *the cutting down of the rain forest* and *the threat to wildlife*. Concerning the other issues, the analysis showed only slight differences between nations: German students considered *packaging* and *nuclear power* to be amongst the three most important issues while English students rated *acid rain* and *river pollution*. There was no significant difference with respect to urban and rural residence or with respect to gender. When both nations were considered together, girls tended to consider *the threat to wildlife* as more important than boys and more boys considered *nuclear power* as very important. When answering open questions, students had difficulties in giving correct reasons for the importance of the issues. The two questions concerning animals evoked the most emotional respect, as one could imagine. The majority of students found it easier to say what others should do but they also expressed their feelings of helplessness when answering the question on what they themselves would do. An interesting result was also that *the hole in the ozone layer* was considered less important than *cutting down of the rain forest* or *threat to wildlife*. In this study Prelle and Solomon expected, based on earlier studies (Solomon 1992), that the life-style of students would form an important aspect of students' attitudes towards environmental issues and answers to these questions. However, according to their study they had to ignore this. It was apparent according to their research findings that German students had more correct information about most of the environmental issues and that they wrote more fluently about them than English students. The researchers suggest that German students had learned more about these issues at school. Also this study convinced Prelle and Solomon that what the answers tell were more social and cultural products than personal or a collection of factors.

Arbuthnot and Lingg compared environmental behaviours, knowledge and attitudes of French and American adults (Arbuthnot & Lingg 1975). Their results confirmed that the Americans' environmental attitudes were more pro-ecological, more internally consistent, and more likely to be related to environmental behaviour and knowledge and other attitudinal and personality variables than those of French adults. They suggest that knowledge may act as a mediating variable between attitudes and behaviour. They also concluded that if the environmental awareness in a culture is high it might influence behavioural commitment. Several years later Lehman and Gerds (1991) wrote that people's environmental behaviour depends on the nature of the environmental issue and how they perceive it. They wrote that if people feel a specific environmental problem to be close to them, it affects their active environmental behaviour. Also some people believe more than others that their own activity may have an effect on the environment (Peyton & Miller 1980, cited in Prelle & Solomon 1996, 91). Because environmental problems may be local or global and some of their effects may extend far beyond our lifetimes, responsibility and concern also depend on the observer's time and location. Environmental issues also have different dimensions with respect to political and sectional interests.

Lyons and Breakwell (1994) examined the role played by scientific knowledge and attitudes toward scientific development. As environmental issues they used industrial pollution and emissions of chlorinated fluorocarbons (CFCs) in their study. Chlorinated fluorocarbons are chemical compounds used as propellants in aerosol spray cans, as blowing agents in the manufacture of foams. They are also used as solvents and cleaning fluids in some industries. These chemicals destroy the ozone layer in the atmosphere. Lyons's and Breakwell's (1994) survey involved 13- to 16-year-olds pupils in Britain. They presented three questions to pupils: whether they were in favour of controlling pollution from industry, whether they were in favour of banning the use of CFC aerosol sprays (*in favour of - neither in favour nor against - strongly against*) and if they were more willing to see more money spent on research aimed to prevent industrial pollution than on some other of eight research areas mentioned (pupils had to choose three of them). They assigned pupils to two groups on the basis of their responses to these three questions. Those who indicated that they were in favour of controlling pollution from industry and wanted to reduce the use of CFC sprays and would like to see more money spent on preventing industrial pollution were assigned to the environmentally concerned group. Those pupils who were neither against not in favour of the first two questions and did not choose industrial pollution as one of the three most important research areas to be given more funding, were assigned to the indifferent group. Lyons and Breakwell had many difficulties when trying to classify and interpret their data. For example, failure to choose industrial pollution as one of the three most funded research areas did not necessarily indicate that the respondent was opposed to environmental protection, but could as well show that he or she was indifferent about the issue.

Leeming and Dwyer (1995) presented a very elegant environmental attitude and knowledge scale in their study. They divided their questions into attitude and knowledge questions. They used true-false questions on verbal commitment and actual commitment as well as an affect-scale. Their attitude scale was a 5-point Likert-type response format (i.e., very true, mostly true, not sure, mostly false, or very false). One example of the question-type (topic *pollution*): *The most pollution of our water sources is caused by: a) dams on rivers, b) chemical runoff from farms. c) methane gas. d) leaks in the rivers. e) human and animal wastes.* The knowledge scale they used consisted of five alternatives for students to choose from. Leeming and Dwyer found out that test-retest correlation was quite high and therefore supported the stability of environmental attitude and knowledge. They also found that the scores of children in grades 1-7 of elementary schools were quite low. These are very important results when we think about teaching because, as mentioned earlier, pupils start to develop their attitudes to certain issues when they are very small. Even though Leeming and Dwyer explained that for many subjects guessing had been the basis for responding, they still found highly significant differences between age groups.

When Simmons (1997) wrote his book, *Humanity and environment*, he intended apart from informing college students about environmental processes and problems, also to show them the diversity of means through which people have come to understand, communicate about, and act on the environment. He wanted to show that even the identification of environmental problems varies across cultural groups, depending on their values. Simmons points out three broad themes in human-environment relations: human population growth and its relationship to resource use, historical and cultural variation in views of the human place in nature, and cultural variation in the use of resources for fulfilling basic need and satisfying desires. Students should be given knowledge for ecological thinking: for example, by teaching how natural sciences proceed and what research tells about the environment and human modification of it, the use of various renewable and non-renewable resources and waste generation as well as waste disposal. In his view, the environment represented to us by the natural sciences dominates because it has reliably supported technological applications, whereas sciences that are concerned with the dynamics of natural systems, ecology and climatology, have less predictive power.

3.1 Making sense of environmental science teaching

What actually counts as successful science instruction depends on what are the most appropriate goals of science teaching. Today it seems to be in fashion in most countries to talk about a **s**cience-**t**echnology-**s**ociety (STS) -type science curriculum instead of the traditional academic science curriculum. Those who favour STS say that science teaching should include both theories and processes of science and also other understandings, such as the relationship between society and science (Bybee 1987; Boomer et al. 1992).

The application of constructivist principles of learning provides a basis for encouraging students to become aware of, challenge inconsistencies in, and make an informed decision regarding their commitment to their own or alternative environmental conceptions (Ballantyne & Packer 1996). When the goal is to achieve environmentally literate citizens, teaching of environmental knowledge, attitudes and behaviour should be taught in an integrated manner. As Ebenezer and Zoller (1993) wrote, students wish to be taught from their own perspectives by relating school science to everyday science in the science classroom. When students are responsible for their own learning and knowledge construction, they will be mentally and emotionally engaged with what they are learning and this will foster more positive attitudes toward science topics. It is, however, important to remember that affecting students' attitudes and knowledge is not always guaranteed, no matter how effective teaching seems to be. It seems quite clear, according to the study of Tung, Huang and Kawata (2002), that the different types of teaching methods had some effect on students' knowledge, but in the case of environmental attitudes and concerns no significant change was found, neither in the area of attitudes nor concerns.

Until now studies have not reached complete consensus on what the most important aims of science education are. Conceptual change studies are concerned with understanding how students progress toward scientific explanations and measure the success of instruction in terms of that progress (Boyle & Maloney 1991). Problem-solving researchers regard correct problem solutions as evidence of success (e.g. Bunce et al. 1991) and science-technology-society (STS) researchers who are highly interested in students' understanding and learning of STS issues assess students' learning based on these things (Rubba 1991). Several studies (e.g. Ajewole 1991) regard students' positive attitude to learning science as important when evaluating the success of science teaching. It is encouraging for educators to learn that attitude can be influenced, at least in part by what is taught in the classroom. When Bradley, Waliczek and Zajicek (1999) studied the relationship between environmental knowledge and environmental attitude of high school students, they found that knowledge and attitude were correlated. This is a very important finding since it means that increased knowledge may help improve environmental attitude.

Extensive discussion of constructivism in relation to teachers' and students' roles and using constructivism as a basis for constructing a science curriculum has been going on for over ten years. Tobin’s study (1993) suggests that incircularity between learning and change makes the construction of personal teaching and learning theories in a specific context necessary. Context dependence also reminds us of the fact that teachers will always do what makes sense to them in the circumstances they encounter in their workplace. Tobin had found earlier, for example, that a teacher who was close to retirement was seemingly unable to improve his teaching performance. He thinks that it is very important that teachers have visions and that they focus on the learning of students by reconstructing the curriculum.

Kellert (1985) reported that 8^{th} to 10^{th} grade students are the most appropriate targets for fostering ethical and ecological appreciation of the natural world. It is also assumed that increased knowledge about the environment promotes a positive attitude.

3.1.1 Science teachers' knowledge

The influence of science teachers’ content knowledge, pedagogical knowledge, and pedagogical content knowledge on planning, teaching, and reflecting is evident (Sanders et al. 1993). Good pedagogical content knowledge enables a teacher to transform content knowledge into a form that students can use. Expert teachers have a wealth of ideas about teaching. They know the ways of integrating common universal science themes and use content-specific teaching strategies. They can also concentrate more on planning and responding to students' questions as well as being more selective in using content demonstrations and laboratory activities. Good pedagogical content knowledge also enables interactive teaching, which is very important when it comes to environmental issues. Expert teachers can be more selective in their use of information. If teachers have limited content knowledge and pedagogical content knowledge, it will limit their interactive teaching, especially outside their science speciality areas.

In addition to scientific knowledge also science teachers' beliefs can affect their teaching. Linda Cronin-Jones (1991) studied the effect of teachers' beliefs and their influence on curriculum implementation by means of case studies. She found that teachers' beliefs about issues, such as how students learn and the teacher's role in a classroom, should in some cases be changed and teachers should focus on the ways their beliefs influence their own teaching. Since the teachers in her study believed that the most important student outcome is factual knowledge, the teachers should be very sure of the reliability of the information they present to their student.

3.1.2 The link between school laboratory and learning

The main purpose of training laboratories at schools when they first began to appear in the early nineteenth century was that they should advance skills. Later more attention was paid to laboratories encouraging social skills such as co-operation (White 1996). Today a school laboratory has many different purposes: acquisition of specific techniques, learning to use different equipment, such as pipettes and pH-meters, and learning to read them accurately as well as learning how to design an investigation to solve a scientific problem; gaining knowledge through investigations and learning to apply it. According to White the main purpose of laboratories is to help pupils' learning and understanding of the scientific facts and explanations. Today we all know that experimental work in the laboratory has many different aspects, such as developing skills, learning to argue and questioning results, helping students to understand the theory and link different topics through laboratory experiments, etc. Teachers try to help students to develop high-level abilities for designing experiments, implementing their plans and analysing their data. Modern day teachers use a lot of open-ended investigations, class discussions on different methods and validity of observations, problem-solving techniques and debates connected to laboratory learning rather than just exercises from laboratory manuals. They try to motivate students to think and understand scientific phenomena with one purpose being that they become able to develop environmentally responsible thinking.

Demonstrations by teachers are also commonly used in science classes today. Teachers should, however, always remember, as White (1996, 765) notes, that "a demonstration may occur in front of students' eyes without them taking any real notice of it." If we want demonstrations to have a long-term effect on students' understanding, they must be memorable and be associated with learners' prior knowledge. There are many excellent demonstrations known that can be used to explain different environmentally important phenomena, such as the greenhouse effect, the catalytic converter, the euthrophication, etc. Science should be dynamic and develop interpretation of phenomena students will observe. There is a good example of this in White's (1996, 770) paper: "The Boyle's law equipment consists of a closed and an open glass tube, connected by a hose filled with mercury. Why mercury, and not water or kerosene? "Does it matter how high the tubes are on the frame, or just the difference in heights?" These questions can be used to improve the exercise.

Students should be taught during different laboratory experiments how to relate one topic to another and at the same time to their own learning environment and everyday life (Asunta & Bader 1993; Asunta 1994). A good linking technique that is quite commonly used in students' laboratories today is concept mapping (Novak & Gowin 1984; Asunta 1999; Kari & Nöjd 2001). This technique can be very useful when dealing with environmental issues and their effects. School science should be related to everyday science in the science classroom and should view science as a method of understanding the world, as stated by Ebenezer and Zoller (1993) in their study. This means that environmental issues should also be dealt with from students' own perspective related to their life and surrounding world. Teachers should remember that students are mentally and emotionally engaged with what they are learning.

4 BELIEVING IN THE MEDIA AND GETTING INFORMATION THROUGH THEM

Many researchers have commented on the possible influence of mass media on their audiences with regard to environmental issues. In their article Fortner and Lyon (1985) refer to several research surveys of environmental knowledge that concentrated on finding out respondents' knowledge sources. Based on those studies it seems that television has been the main information source in the 1970s and 1980s. Fortner and Lyon were convinced of the importance of television as an information source for the general public as well for pupils. It was also reported by Disinger in the 1990s that spupils' primary sources of information about the environment is not the classroom but television and other mass media (Disinger1990). He also stated that students' knowledge of the environment is limited and incomplete. In the present study environmental information means information from any source that deals with environmental issues and environmental problems.

Winett and others (1984) demonstrated that television programs had effects on viewers' home energy conservation practices. Ostman and Parker (1987) focused in their study on the effects that education, age and consumption of environmental information that people gain from newspapers and television have on people's environmental knowledge, concerns and behaviour. They used respondents' education, age, use of newspapers and use of television for environmental information as independent variables in their study. The dependent variables were environmental concerns, environmental knowledge, level of environmental awareness, attention to environmental content, the frequency of mass media use for environmental information and subsequent behaviours that were environmentally positive. They found that attention was related to awareness in the predicted direction, knowledge, concerns, and subsequent behaviour. They also found that knowledge was related to concerns and subsequent behaviour, as was also environmental concern. According to their study there was a significant positive relationship between education and environmental awareness, knowledge, and subsequent behaviour. Age was not found to be related to attention, awareness, subsequent behaviours, or frequency of mass media use for environmental concern.

Their results also showed that newspaper use was related to attention, concerns and subsequent behaviours but, interestingly enough, not to knowledge. As expected, television use was not related to attention, awareness, and concerns of subsequent behaviours, neither was education related to age, television use for environmental information or to newspapers use for environmental information. Age was also not found to be related to television nor to newspaper use for environmental information. Education was found to be positively related to environmental knowledge. According to Bailey (1971), education proved to be strongly related to information. His study clearly shows that those persons with university degrees gain more knowledge through the media than those who do not have academic degrees.

According to Blum's study, the mass media were in the late eighties one of the main sources of information about environmental issues for young people. The mass media can be effective in focusing attention on different problems (Blum 1987). However, they are much less suited to presenting the facts behind these problems or educating students to analyse different problems and situations they cause. The mass media neither taught pupils to identify the factors that have contributed to the problems nor to weigh up alternatives or suggest solutions for them. These abilities can only be achieved through education. However, Blum's review showed that school was a less common source of environmental information than the mass media. This means that schools have a lot to do to improve the knowledge base of students if they are supposed to realise the seriousness of various environmental issues (Brody 1994).

If direct experience produces affective-based attitudes, then the source of the information on which an attitude is based is important in furthering development of this attitude or the development of related environmental attitudes (Pooley & O'Connor 2000). As mentioned in the previous chapter, Lyons and Breakwell (1994) considered in their research article the relative role of media amongst the environmentally concerned as well as amongst various other groups. As Detjen (1995, 58) noted in his article, "the media's role in science education is an important topic because - like it or not - it is through newspapers, magazines, radio, and television that people learn most of what they know about the environment." He wrote that according to a survey made in US environmental issues is the subject that young readers want to read about. Also based on a survey made in the US, the public would like to have more information about science and environmental issues in the media and many people think that science is as important as politics, crime and business. According to Detjen's paper, the general level of scientific knowledge in the US is very low, even among educated people.

We live now in an information society that, according to Sale and Marien (1997, 14), is also consumer society. They wrote that "information has quite suddenly become the world's most important resource" and that "as far in the future as we can see, information will be playing the prima donna role in world history that physical labor, stone, bronze, land, minerals, and energy once played." Information is readily transportable, it leaks and is shared. All this can easily be seen when looking at the results of the present study. Goldsborough (1999, 13) asked a question in his article: "Can you ever trust the Internet?" And answered: "sure you can." He stressed that people need to apply critical thinking in evaluating the information. People in Finland are very critical in their relation to the media and they are of the opinion that media with their editors play too important a role in leading people's opinions (Anon 2001).

5 RELIABILITY IN ENVIRONMENT AND BEHAVIOUR RESEARCH

In my opinion Levine (1994, 266) who has examined reliability in environment and behaviour research, very clearly has expressed the reliability and validity of these types of research: The measurement of the reliability of the instrument used is an important aspect in the research. For measurement to be useful one must be sure that:(a) observations can be repeated and (b) the measurements correspond to the intrinsic features of the objects being measured. These requirements refer to the reliability of measurement and to the validity of measurement, respectively.

To achieve perfect reliability, each individual should obtain the same score each time that measurement is taken. Levine (1994) states that researchers should turn instead to standard methods, such as intra-class correlation or generalizability theory.

In a recent review of 34 studies that attempted to measure the effectiveness of environmental education, Leeming and others (1993) found 33 studies that incorporated an environmental attitude or knowledge scale designed for children. All but one of these studies employed a project-developed questionnaire to measure attitudes and/or knowledge, that is, a scale that was created specifically for the particular study. Obviously, no single scale is widely used to measure children's attitudes toward and knowledge of a broad range of environmental issues. It is essentially impossible to make meaningful comparisons across these various studies because the comparability of the instruments is unknown. Typically, the authors of the reviewed studies provided very little information about the reliability of their respective instruments and virtually nothing was reported about validity, other than an assertion that the items were developed and selected by knowledgeable "experts." Although expert opinion is important in scale construction, researchers should also use other forms of scale validation.

In their study Van Liere and Dunlap (1981) tried to find an answer to the question of whether it makes a difference how environmental concern is measured. They investigated the comparability of different types of environmental concern measures and explain that measures vary in the extent to which they incorporate different environmental issues, such as pollution and natural resources. Some researchers have measured attitudes toward, for example, pollution and natural resources as distinct dimensions of environmental concern (Tognacci et al. 1972), but more common has been to combine items dealing with these differing issues into a single environmental concern measure (Maloney & Ward 1975). According to Van Liere and Dunlap, it is, however, unclear whether attitudes toward these various substantive issues equally reflect broader environmental concern.

6 METHOD

The different stages of the research are presented in figure 6.

The pilot study /1993
Questionnaires A & B presented to a sample of Finnish students
Analysis of the results
The actual study 1/1996
Training of teachers and student teachers for data collection
Interview of teachers involved
Active laboratory session ▪ Experiments 1-5 carried out by pupils and sessions evaluated by teachers, student teachers and the researcher
Modified questionnaires A and B presented to students in five Finnish schools and one school in Frankfurt, Germany.
Analysis of the results
The actual study 2/2000
Questionnaires A and B, completed with questions concerning the Internet, presented to students in five Finnish schools and one school in Frankfurt, Germany.
Analysis of the results

FIGURE 6 The research setting

The qualitative research techniques used in the study consisted of constant comparison analysis and triangulation (Glaser & Strauss 1967). As a part of the triangulation process, data were obtained from a variety of sources and compared in order to find answers to the research problems presented.

Data collection in this study consisted of three main parts:

1. **The preliminary pilot study** that was carried out during 1993 was used in planning the first and second sampling of the actual research study. It only consisted of questionnaires A and B. Questionnaire A measured pupils attitudes' and opinions toward certain environmental issues, as well as their self-reported behaviour, and questionnaire B measured information sources that students used when gaining information about certain environmental issues. Questionnaire A consisted of 60 questions partly similar to those later used in the actual study and Questionnaire B was the same as used in the final study.

2. **The first data collection** that took place during 1994 - 1996 was the main sample of the research. It consisted of: a) teachers interview (appendix 5), b) written questionnaires A including 34 items and B (appendix 1 and 2), and c) classroom observations during practical experimental one-hour laboratory sessions (appendices 3 and 4) in 4 schools in Finland and only written questionnaires A and B in one school in Frankfurt, Germany.

The researcher interviewed eight teachers from the schools chosen to represent the Finnish sample. Each of the teachers was asked the same questions (Appendix 5). A taperecorder was used to collect their answers and they were transcribed afterwards by the researcher.

Classroom observation consisted of teachers' report, who recorded carefully what happened during each active laboratory periods by writing field notes as well as discussion with observers after each one-hour experimental session, and the observations and notes of the researcher. Student teachers also used video technology during the laboratory sessions. Teachers' notes included verbal descriptions of the setting, the name of the students they followed more precisely (4-5 at a time), the substance of what the teachers and/or students said and how students acted (behaved) in different situations during the laboratory sessions and the observers' comments, including reactions, hunches and initial interpretations. In eight different classrooms 18 laboratory sessions, each of the 45 minutes duration, were observed and detailed field notes were obtained by connecting the notes of each observer. The total attendance of pupils in the laboratory session was 304 since some of the 160 students took part in one to four laboratory sessions.

Since there is a variety of environmental concerns, most of which could be covered by asking straightforward questions, I chose the questionnaire as the main instrument in finding out pupils' information sources on environmental issues (Henerson et al. 1987). A sample of convenience was used when choosing Finnish schools for this study. However, there are no indications that they differ in any way from other secondary schools in Finland. According to Linnankylä (1993, 1995) and Välijärvi and Linnankylä (2000), school variance in Finland is small. One large German school included in this study was also a sample of convenience chosen to be compared to some country in the European Union.

One large school in Frankfurt was chosen because my adviser knew one teacher in this school who could run a questionnaire there.

The researcher first interviewed all chemistry teachers in Finland whose pupils took part in the study. Secondly, laboratory sessions were arranged in their classes and thirdly, two to eight weeks after the active laboratory sessions, all these students and a large numbers of other students with this same teacher answered the questionnaires. The outline of the whole study is presented in Figure 7.

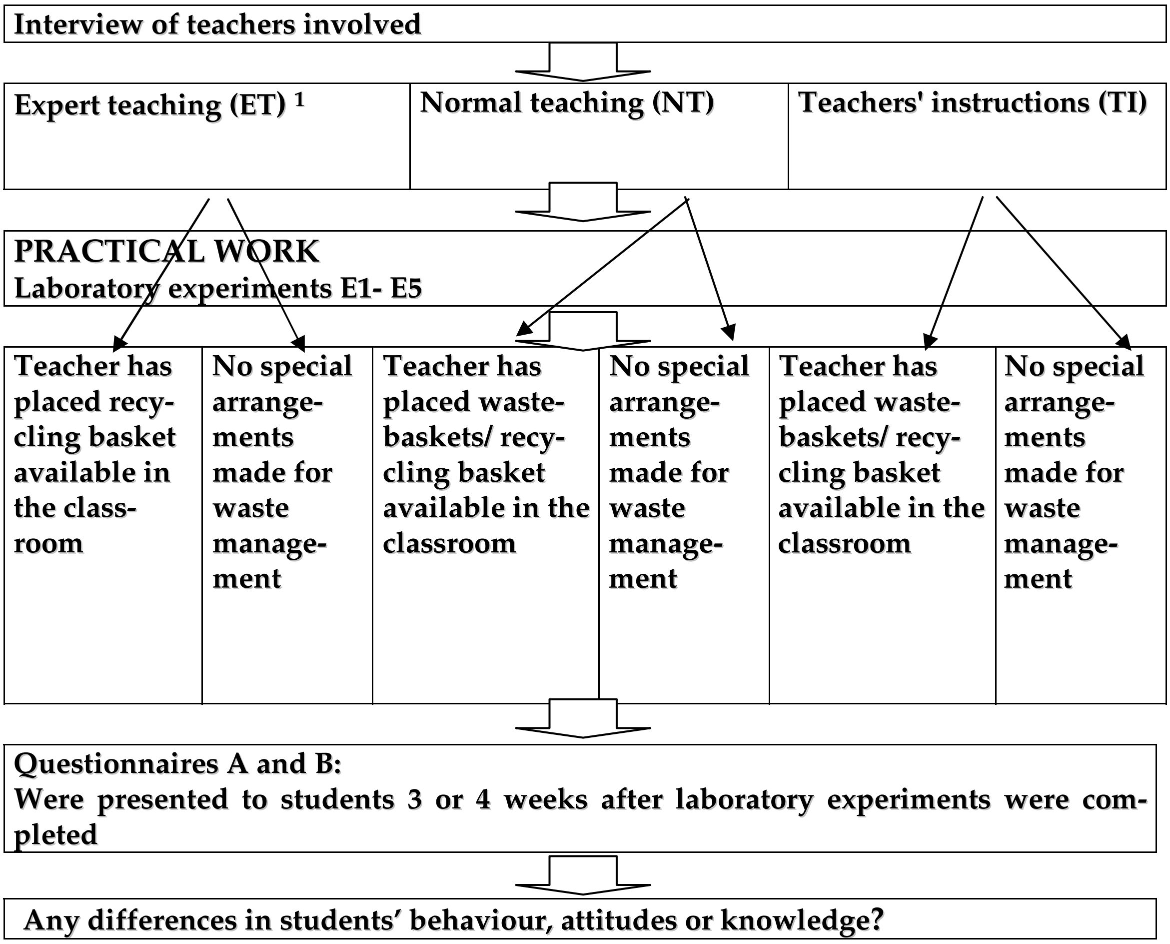


FIGURE 7 The main outline of the research

3. The second data collection was carried out during 2000 for comparison and to indicate changes caused by time. It consisted of written questionnaires A and B administered in four schools in Finland and one large school in Frankfurt-am-Main, Germany. An additional information source, the Internet, was introduced in questionnaire A in the present study.

[1] ET, NT and TI explained in more detail in chapter 6.3.2

6.1 The research problems of the study

The purpose of this study was to examine:

1. The information sources that students use to gain their environmental knowledge.
2. What students' subjective self-reported estimation of their own attitudes towards environmental issues is.
3. The possible correlation of students' environmental behaviour based on their own estimation with their environmental attitudes.
4. If there is correlation of information sources that students gain their environmental knowledge from and their environmental attitude and behaviour.
5. Students' environmental behaviour in the laboratory.

The empirical part of this research focused on the following problems:

1. Which are the main information and knowledge sources from which students at the age of 12 to 15 gain information on certain environmental issues and how familiar are these issues for them?

1.1. Are there any meaningful differences in the information sources and familiarity of certain environmental issues between some Finnish and some German pupils representing a sample of convenience?

1.2. Do the genders differ when looking at the familiarity of the main information sources on certain environmental issues and are there differences between a certain sample of convenience of Finnish and German pupils in this respect?

1.3. Are there any meaningful differences between the age groups when looking at the sources of information?

1.4. Which are the most common environmental issues for 12 to15-year old pupils?

2. What is students' attitude towards environmental issues in general based on their self-reported estimation of attitudes and behaviour?

2.1. Is their attitude towards chemistry and the chemical industry positive or negative?

2.2. What is pupils' attitude towards learning chemistry?

2.3. How do pupils estimate their own environmental opinions and behaviour? How much do pupils trust information gained from different sources?

2.3. Have there been noticeable changes in students' attitudes and information sources during this study as far as environmental issues are concerned?

2.4. Are there any noticeable differences between schools with regard to attitudes?

3. Do pupils' attitudes and behaviour correlate?

4.3. Do the information sources have any effect on pupils' environmental opinions, attitudes or behaviour?

5. Do pupils behave in an environmentally responsible way in the laboratory?

5.1 What influences pupils' behaviour in the laboratory?
5.2 What is the effect of teaching on their behaviour?

In this study environmental concern measures are based on a Likert-type attitude scale (questionnaire) as well as a laboratory behaviour classification scale (experimental laboratory part). Based on the model of Van Liere and Dunlap (1981) all of the environmental measures are influenced by environmental concern (figure 5). Their results proved that the different environmental concern measures are highly inter-correlated (a's and b's in figure 5). If this model is correct, two types of consistency should be found in my work among the observed correlations (a's and b's in figure 5). Van Liere and Dunlap (1981) hypothesised that correlations between environmental concern measures and variables such as age, gender, etc. would be approximately equal. Their study proved that as long as they limited themselves to cognitive measures of concern with pollution and/or natural resources, they found a considerable degree of consistency in the observed results. When examining Likert-type attitudinal items, all but behavioural measures were found to be strongly inter-correlated (as long as the issues were restricted to pollution or natural resources). It seems that "environmental concern" is a concept that will be best described in terms of pollution and natural resources. Their study proved that different types of environmental concern measures and social variables, such as age, gender, etc. are related in different ways. They strongly suggested that more attention should be paid to the measurement of environmental concern.

6.2 Teachers and student teachers involved

Teachers of four Finnish schools that were chosen for this research represented a sample of convenience. They were asked before the final sampling if they had a special environmental course in their school programme and, if they had, at what time of a year the course was usually taught. From these schools three such school classes were chosen for this study who had an expert teaching period on environmental science within six months before this study was carried out. Schools represented different parts of Finland, some situated in the cities and some in villages close to cities. They were not in any way known to represent schools with good or bad results, either in chemistry or other subjects.

The final study consisted of a sample of convenience of eight Finnish chemistry teachers from four different schools referred to in this paper as Teacher 1 - Teacher 8, who were teaching a seventh, eight, or ninth grade, and who agreed to collaborate. They were first interviewed (appendix 5) and advised to document observations of students' behaviour during laboratory experiment session.

Eight subject student teachers were involved in helping the main investigator to carry out the laboratory sessions and to observe students' behaviour during them. They were also advised to document observations while pupils were working.

6.3 Data collection

After a pre-study that was carried out during 1993, the data collection for the present study took place from September 1994 to May 1996 and the second data collection from January to May 2000. As the result of the pre-study the amount of questions in questionnaire A was reduced from 60 to 34.

The first part was the interview of the chemistry teachers in those classes where I was going to introduce the questionnaires and laboratory session. All interviews were conducted in person by myself and were tape-recorded. After this the chemistry teacher, three student teachers (one or two at a time) and I as the principal investigator observed the classes during active laboratory sessions when pupils were carrying out the experiments. Each teacher and the student teachers present were asked to collect information on the classroom context according to the oral instructions given to them by the main investigator in a meeting before the laboratory session (Henerson et al. 1987). They were asked to write down all their observations - which somehow concerned environmental issues - during the laboratory session as specifically as they could (pupils' conversation with their partner and other pupils, who would make certain decisions concerning the handling of chemicals, etc.).

The basic form given to them for use during the session is presented in appendix 4. The students were divided into as many groups as there were observers and each observer followed four to five pupils at a time depending on class sizes and activities students were carrying out.

Approximately one month after this, they were examined by a written test that consisted of two different types of questionnaires: Questionnaire A (QA, appendix 1) and Questionnaire B (QB, appendix 2). Teachers and students of schools were notified of the days when the observer and investigator would be in their school as well as the days when the questionnaire would be administered.

Finnish students were examined by using two types of written questionnaire, which were developed during this research based on the studies of Müller-Harbich and others (1990 a, b), and private communications (Bader 1992), as well as one to five laboratory experimental activities - chosen for this purpose by the researcher - in which students engaged. The laboratory sessions were observed by using classroom observation technique. Students were aware of being observed. However, every effort was made not to point out which particular students were being observed. The teachers usually informed the students that the observers were there just to see how they generally worked during laboratory sessions. Individual students were observed with reference to their interactions with teachers and/or peers and the purpose of such interactions, the settings in which the observed behaviours occurred, the types of actions the students were using and questions they were asking during and after carrying out the experimental activities. German students were examined only by the written tests.

The written test had two parts: Questionnaire A (QA) and Questionnaire B (QB). The purpose of the QA, which consisted of 34 statements (appendix 1), was to find out how much knowledge students in general have of certain things that are associated with environmental chemistry and what types of attitudes they have when environmental issues are concerned: to test their environmental concern. The purpose of QB (appendix 2), was first to study how much students know about certain environmental issues: to find out their environmental subject knowledge. The second purpose of this QB was to study from which sources students gain their information.

Active laboratory-period observation analysis was used to test students' behaviour during and at the end of the laboratory session. Arrangements were made to observe regular classroom instruction during classes devoted to special activities. Altogether 5 classes of grade 7, 4 classes of grade 8 and one class of grade 9 were evaluated by observation. Each student was observed for 2-3 intervals during the 45-minute data collection period. This could be described as a situational technique: the pupils were faced with a realistic situation and were forced to choose what to do or what to ask from a number of options available (Lave 1996). The laboratory session design was based on the scheme presented in figure 7. The total number of students involved is presented in figure 8.

Five special laboratory experiments (E1-E5) were used in this study. These experiments are presented in more detail in appendix 3. Just to be sure that it was not only the experimental planning or working context that affected the students' behaviour, several students were observed during different laboratory sessions when they carried out different types of experiments. A total of 160 Finnish students took part in one or more of five different laboratory sessions (75 students from grade 7, 76 students from grade 8, and 9 students from grade 9). Students from grade 9 were included just for comparison since chemistry is not taught at grade 9 in Finland.

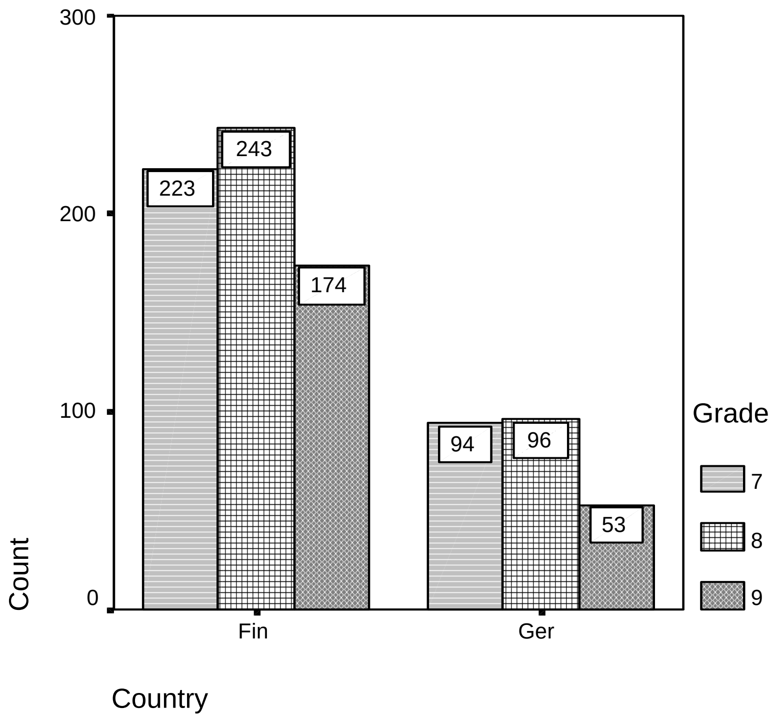


FIGURE 8 The numbers of students of different grades answering the questionnaire or taking part in one or more of the laboratory sessions

6.3.1 Sampling of the students

The subjects of this study were a cluster sample of secondary school students aged 13- 15 years from different parts of Finland and from Frankfurt, Germany. The schools in this research were chosen as a sample of convenience from those located in central Finland and, for comparison, one school from northern Finland and one large school from Frankfurt were included. The other argument for the sampling of Finnish schools was that the teachers were willing to co-operate. Also a sample of convenience was used when selecting classes and students as well as gender of students for this research (Borg & Gall 1989, 200). The reason for this choice was that I wanted to have some city and countryside schools as well as to have some variation of district in Finland. Also since Finland belongs to the European Union, I also wanted to have some comparison with some other European school. Because our department has a student and teacher exchange programme with the University of Frankfurt, it was natural to include one school from that city as an example in my study. Even though the Finnish schools included in this research were a sample of convenience, they were chosen after interviewing the chemistry teachers to make sure that some of the teachers involved had had an expert teaching period on environmental science within six months before this study was carried out. The pupils for the experimental tests were picked from the classes by the researcher just before the classes started. The only purpose was include approximately the same amount of boys and girls. The researcher did not know the knowledge base nor anything else from these pupils beforehand.

The pilot study that was used to design the actual research consisted of 150 students in the 7th to 9th grade of four secondary schools in central Finland and one school in northern Finland. Pupils in these five schools were presented with the written questionnaires similar to those used later in the actual study, but the number of questions asked was larger (60) compared to the actual study (34).

The subjects of the first sample of the actual study were thirteen to sixteen-year-old students of three large secondary schools in central Finland, one in northern Finland and one large secondary school in Frankfurt, Germany. Within each school year and gender, the sampling was strictly a sample of convenience. A prerequisite for selection was that the class had had an expert teaching period on environmental science within six months before this study. Three such classes were selected. All Finnish students (N = 339) and German students (N = 193) took part in the written questionnaire, so the total number of participants was 532. The gender distribution among these students was nearly equal: 166 girls and 173 boys from Finland and 97 girls and 96 boys from Germany. Of this numbers only 160 Finnish students took part in the laboratory session and 91 students attended more than one laboratory session. These students were also randomly chosen from different classes.

The gender distribution among these 160 students observed was 69 boys (43.1%) and 91 girls (56.9%). Table 1 displays the frequency distribution of students observed by grade and gender and table 2 the total number of students filling the questionnaires during the first phase of the research.

TABLE 1 Students observed during the laboratory sessions

	Gender		
Class grade	Boys	Girls	Total
7	35	40	75
8	32	44	76
9	2	7	9
total	69	91	160

TABLE 2 Finnish and German schools and students taking part in the written questionnaires

School	Boys	Girls	Total
School 1 (Fin)	33	44	77
School 2 (Fin)	42	43	85
School 3 (Fin)	50	34	84
School 4 (Fin)	48	45	93
School 5 (Ger)	96	97	193
Total	269	263	532

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The subjects of the second sample of the comparison study consisted of students from the same schools as in the actual study and represented the same age groups but they all took part only in the written questionnaire. At this time 301 Finnish students and 50 German students were involved. With this new sample I wanted to study if there had been changes in students' attitudes towards environmental issues in four years.

Although the school classes selected were randomly picked, three of them were chosen for having had an expert teaching period on environmental science within six months before this study was carried out. This choice was necessary for comparison.

Although the reasons for this selection were mainly practical, these student groups represent sufficient variety for the needs of this study.

6.3.2 Teachers interview

To gain some pre-information eight chemistry teachers involved were interviewed before the laboratory session. The primary purpose of the interview was to find out if the students had had a special environmental chemistry course (expert teaching, ET). Secondly, I wanted to find out how they usually gave instructions concerning laboratory waste; if they gave them at the beginning of each course (normal teaching, NT) or at the beginning of each laboratory session (teacher's instructions, TI). A third purpose was to find out the attitude of the teacher on environmental issues in general, and if they thought themselves **e**nvironmentally **c**oncerned **t**eachers (ECT) or **e**nvironmentally **n**on-**c**oncerned **t**eachers (ENCT), as well as how they thought they transferred their concern to their pupils. All eight teacher interviews were conducted in person by a research assistant or the principal investigator and were tape-recorded. The questions presented concerned teachers' environmental activity in teaching as well as their attitudes and behaviour (Appendix 5).

Teachers were not allowed to see the written questionnaires (appendices 1 and 2) which their students answered. After the interview teachers were informed that they should make notes on their students' environmental behaviour during the active laboratory period of testing. They were told that they would get more information concerning the evaluation part in a meeting arranged before the laboratory session (to be explained in the next chapter).

6.3.3 Active laboratory period experiments and observations

The students for the experimental science tests were picked randomly from grade 7 to 9 without any knowledge of their level of intelligence. These students carried out certain laboratory experiments (E1- E5) designed to test their environmental behaviour during and after carrying out the activity.

Students’ behaviour was evaluated during different laboratory sessions using the following methods:

a. observing (researcher, student teacher and chemistry teacher)

b. using teachers' field notes (student teacher and students' own chemistry teacher)
c. using diary notes (researcher) and videotapes (student teacher).

The principal investigator, the chemistry teachers of each class involved and five student teachers (one or two at a time) collected data for the study during an active laboratory session. They were all informed by the researcher beforehand what they were expected to do. They were supposed to record carefully what happened in the classroom during each session by writing field notes. These notes included verbal descriptions of the students' conversation but were mainly focused on what they were doing. The observations and notes they made during the session were discussed after the laboratory period during a session arranged between them and the researcher and written down by the researcher. Also the diary notes made afterwards by the researcher or chemistry teacher (depending on who did the teaching - their own chemistry teacher or the researcher) were used for analysing students' behaviour during the active laboratory working session.

The chemistry teacher of the class and student teachers were asked to write down any information concerning pupils' conversation with their classmates, their teacher or other students and what they did while carrying out the laboratory experiments, specific regard for students' environmental behaviour. They were asked to pay special attention to the moment when students started to clean their desks after they had finished the experiment in question: what they did with the waste. While making notes, the student teachers were also advised to discuss with the students, but they were absolutely forbidden to give them any advice on how to deal with waste. The researcher made observations and notes both during and right after the sessions. At the end of each sessions, the researcher, chemistry teacher and student teachers had a meeting and they discussed the observations and the researcher made her notes based on this discussion.

The following laboratory experiments were used during this research:
Laboratory experiments (E1- E5):

- Electrolysis (E1)
- Testing batteries (E2)
- Reactivity of metals (E3)
- Beating hearts (E4)
- Synthesis of a superball (E5)

The experiments are presented a more detail in appendix 3.

Students who took part in the laboratory sessions had different teaching (see below) or instructions before starting their experimental work:

One part of the students had had the special environmental chemistry course/ **e**xpert **t**eaching **(ET)** two months before the test: a 38-hour course, including both theory and active laboratory practice approximately in an 1:1 ratio. The teacher did not give any special advice during the laboratory test.

Another part of the students had attended a normal chemistry course/ **n**ormal **t**eaching **(NT)** just before the test**,** including both theory and practice (approximately 1:1 ratio): also a 38-hour course. The teacher did not give any special advice during the laboratory test.

A third part of the students was attending the normal chemistry course. Their teacher gave them instructions concerning wastes/ **t**eacher **i**nstructions during the laboratory working session **(TI).**

Pupils belonging to these three groups carried out one to four of the laboratory experiments (E1-E5) and were observed during the experimental session. The total amount of pupils evaluated was 160. In each of these cases two different kinds of arrangements were evaluated:

1. The teacher had arranged wastebaskets to be available in the classroom but did not especially mention the presence of them to the pupils.
2. No special arrangements were made for waste management.

At the conclusion of the observation session, the behaviour of pupils was observed in each separate case and I rated teachers comments using the classification scale presented in table 3.

TABLE 3 The seven categories (B1- B7) into which the students' environmental behaviour during the laboratory session was categorised

Pupils' behaviour (B)	What pupils did (Yes = 1; No =0)
B1	Pupil follows the teachers instructions given during the class.
B2	Pupil threw the waste into the sink or ordinary wastepapers basket.
B3	Pupil returned the waste to the desk, from where they had picked up the equipment and chemicals that they needed.
B4	Pupil asked the teacher what should be done with the waste.
B5	Pupil asked the teacher if he could throw the waste into the sink.
B6	Pupil put the wastes into the wastebasket or the basket reserved for it (just on their own; without asking anything).
B7	Pupil asked if there are any wastebaskets available.

The observations, teachers' field notes and information on discussions with teachers after each laboratory session and videotapes were analysed. The results were recorded as follows: if the answer to the statement was yes, it was coded using the number one, and if the answer was no, it was coded using zero.

The behaviour of pupils in case of different laboratory session was analysed. In order to find out differences in behaviour concerning the three groups that had got different kind of teaching or instruction (NT, TI, ET), the behaviour was divided in the following way: B2 and B3 were classified to represent *environmentally **n**on-**r**esponsible **b**ehaviour (ENRB*) and B1, B4, B5, B6 and B7 were classified to represent *environmentally **r**esponsible **b**ehaviour (ERB)*. The behaviour of pupils was evaluated and recorded in each separate case and categorised using this classification. B3 was classified to present ENBR because pupils chose the easiest way to get rid of waste without bothering to ask or think.

The same pupil was evaluated during different sessions to find out if the behaviour of an individual pupil differs from experiment to experiment. For this reason 91 pupils carried out several experiments. The numbers of pupils taking part in the different experiments are presented in table 4.

TABLE 4 The numbers of pupils in different laboratory activities

Electrolysis	N=34
Battery test	N=65
Metals	N=147
Beating heart	N=44
Making a superball	N=14
Total	N=160

6.3.4 Environmental attitudes and opinions

Questionnaire A (Appendix 1) was used to measure pupils' knowledge and attitudes concerning different environmental issues. This was necessary in order to be able to test the correlation between pupils’ behaviour, knowledge and attitudes. Questionnaire A contained two sections: (1) background questions and (2) 34 items with responses on a five-point Likert-like scale concerning environmental issues

either *(a) always (1), often (2), sometimes (3), seldom (4) and never (5)*
or *(b) I totally agree (1), I almost agree (2), I partly agree (3), I almost disagree (4) and I totally disagree (5).*

This scale was similar to that used, for example, in the study of Lyons and Breakwell (1994). Pupils were presented with 34 statements and they were asked to circle the number that they thought best described their opinion. The researcher identified four categories that were later used in the analysis. For analysis ten statements were classified to describe pupils' *general attitude* on environmental problems (questions 1-10), ten statements to describe their *attitude towards chemistry and the chemical industry* (questions 11- 20), twelve statements to describe pupils' *personal opinion and environmental behaviour* (questions 21-32) and two statements to describe pupils' *believing in information* (questions 33-34). In the questionnaire presented to pupils this classification was not seen. My reasoning for this decision is based on the studies of Leeming and others (1993) which is described in more detail in the chapter 'validity of the research'. A quite similar type of questionnaire to the one used in the present study but with a 7-point scale was used by Vogel (1996, 601) when he studied farmers' general attitude toward the environment. His statements were of a similar type to mine such as "I do not believe that the environment is as polluted as people say" or "air quality is becoming worse because of dust and poisonous substances". In their study Ebenezer and Zoller (1993, 177-178) classified pupils into three groups in terms of their attitudes toward school science, namely "positive", "neutral" and "negative". They used, for example, the following type of statements: 1) I like to study science at school, 2) Science is dull, 3) I would like to study more science, etc. Also Goodwin and others (1981) used a 5-point Likert-type scale when they studied pupils' attitudes to school, science and science lessons. They used the responses "strongly agree", "agree", "not sure", "disagree" and "strongly disagree".

6.3.5 Information sources

Questionnaire B (appendix 2) was used to measure the amounts and types of information sources from which pupils get their environmental information. It contained eight items concerning environmental issues and 13 (in the first run) to 14 (in the second run) information sources where one could have obtained the information concerning these issues. Pupils were asked to put a tick in all the boxes that applied to them. This way one pupil could mention more than one source for each environmental concept.

Using questionnaire B (appendix 2) in the first sampling, the pupils were asked to indicate where they got their information on certain environmental concepts. The eight issues concerning environment studied in this research were:

a) catalytic converter
b) ozone hole
c) acid rain
d) exhaust gases
e) greenhouse effect
f) water pollution
g) harmful substances
d) recycling

and the information sources investigated using the questionnaire were:

1) TV and radio
2) newspaper or magazine
3) movies
4) friends
5) science teacher (physics,chemistry or biology teacher)
6) some teacher (other than a science teacher)
7) parents
8) Greenpeace or WWF
9) other nature conservation organisation
10) consumer organisations
11) municipal authorities

If a pupil did not know the source or the concept, he/she could choose:

12) I do not know where I got the information from
13) The concept is unknown to me

In the second sample (2000) the eight environmental issues were the same but one more information source, the Internet, was added. So the number of information sources was 14.

This distribution of items should reflect pupils' perceptions of environmental issues, attitudes and most common information sources. Pupils were asked to mark all possible information sources (see Questionnaire B).

In the first run (1996), 532 pupils (N= 339 Finnish pupils and 193 German pupils) answered the questionnaire concerning information sources on environmental issues. In the second run (2000), the total number of pupils participating was 351 (N= 301 Finnish pupils and N= 50 German students). Due to timing difficulties the amount of German students was smaller than intended.

7 RESULTS

The main outline of the research is presented on page 51. It consisted of four different parts. The pupils' answers to questionnaire A were analysed using SPSS-10.1 for Windows.

7.1 Information sources

The new variables were calculated by counting the number of environmental concepts marked for each information source. The range of the variables was hence from zero to eight, depending on the amount of information that the pupils indicated they had gained from the eleven (or twelve) information sources (appendix 2, questionnaire B). Using these variables, it is possible to compare the frequencies of the information sources marked by the pupils and also to compare the answers of the girls and boys, pupils from the two countries, and pupils of different class grades.

When comparing the answers of the different groups, an estimation of the differences could have been made using a t-test for the above described variables. However, because the formed variables are not normally distributed, non-parametric methods were chosen, even though the samples are large. Possible differences between the groups were confirmed using cross-tabulation and chi-squared analysis. To enhance the quality of the chi-squared analysis, the values of the variables were regrouped into five classes : 0 marks, 1-2 marks, 3-4 marks, 5-6 marks and 7-8 marks.

The method of cross-tabulation and chi-squared analysis was chosen because it is more illustrative than other non-parametric methods. However, the Mann-Whitney (M-W) test for testing the differences of two groups was used to ensure the results of the chi-squared analysis. The M-W tests gave the same results as the chi-squared analysis and their statistics are not included.

When the different class grades were compared, the non-parametric correlation coefficient was used. Before the analysis, the German class grades 8, 9 and 1 were re-coded to correspond to the Finnish grades 7, 8 and 9, respectively.

7.1.1 The main information sources of pupils' environmental knowledge

The 1996 study

As expected, TV and radio are the main source of environmental information for secondary pupils followed, by science teachers and newspapers (table 5).

The table shows that on average pupils had got information about more than five environmental concepts from TV and radio. The numbers have been converted into percentages by comparing to a situation where all pupils obtained information about all eight concepts from the source in question.

TABLE 5 The use of information sources for all pupils in the study

	N	Mean	%
TV and radio	528	5.11	63.9 %
Science teacher	528	4.16	51.9 %
Newspaper or magazine	528	3.32	41.5 %
Parents	528	2.14	26.7 %
Other teacher	528	1.14	14.3 %
Greenpeace or WWF	528	1.11	13.9 %
Friends	528	1.06	13.3 %
Movies	528	0.98	12.3 %
Conservation organisation	528	0.94	11.8 %
Consumer organisation	528	0.51	6.4 %
Municipality	528	0.49	6.2 %

The above percentages are statistically accurate to within 1.2 to 2.7 percentage points. Thus, it can be concluded that the main information sources are, in order of importance, TV/radio, science teachers, newspapers/magazines and parents. Information from consumer organisations and municipalities seems to have the smallest importance.

Very similar results were recorded in Rockland's paper (1995, 13) at the same time as I was running my questionnaire. He wrote: "TV is clearly kid's top choice for getting environmental information". These results are also similar to the results of Blum (1987) and those of Roth and Perez (1989), who showed that the mass media are one of the main sources of information about environmental issues for young people. According to Mikkola (2001, 95), at the beginning of 2000 mass media were still the most important information source for 85 % of people as far as environmental issues are concerned. It is interesting to see how time has changed the importance of information sources since Bailey's study in the early seventies (Bailey 1971). He showed that newspapers were at that time the most important information source on an environmental "earth day" concept and television was ranked only fourth in importance. Before the arrival of television, interpersonal information and some other information sources such as leaflets, posters or badges were important at that time. Bailey's study also proved that neither age nor gender had very much effect on knowledge gained through the media.

The 2000 study

The 2000 study was similar to the earlier one, except that one more information source, the Internet, was studied. The results are examined by comparing them to the results of the 1996 study. The purpose was to find out if there are meaningful differences.

It seems that Internet use does not yet compete with the main information sources, but it has reduced the importance of TV and radio as well as of newspapers in Finland. It has not, however, affected the role of science teachers. Overall, it seems that the number of information sources on environmental matters has reduced during the period 1996-2000 (table 6).

TABLE 6 Information sources of Finnish pupils in 2000

Information source	N	Mean	%
TV and Radio	301	4.31	53.9 %
Science teacher	301	4.19	52.4 %
Newspapers or magazines	301	2.47	30.9 %
Parents	301	1.40	17.5 %
Other teacher	301	1.06	13.3 %
Internet	301	0.81	10.1 %
Movies	301	0.72	9.0 %
Friends	301	0.67	8.3 %
Conservation organisation	301	0.65	8.1 %
Greenpeace or WWF	301	0.63	7.8 %
Municipalities	301	0.49	6.1 %
Consumer organisation	301	0.34	4.2 %
Does not know the source	301	0.61	7.6 %
Unknown concept	301	0.55	6.9 %

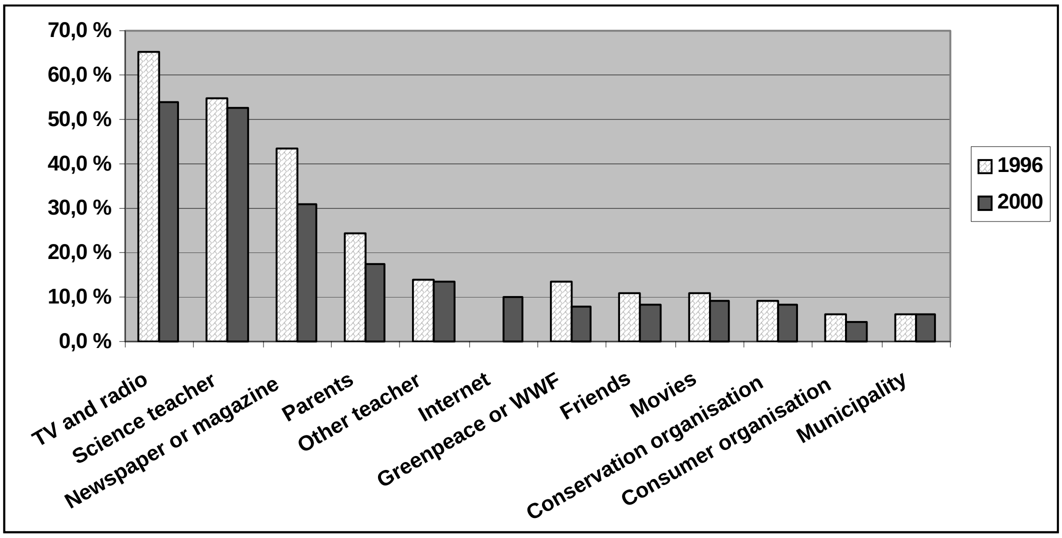


FIGURE 9 Information sources of Finnish pupils in 1996 and in 2000

7.1.2 Comparison of importance of information sources in some Finnish schools and the school in Frankfurt, Germany

The order of importance of the above mentioned four most important information sources was the same in the Finnish and in the German samples. The order was: Television and radio, science teacher, newspaper and parents. This study clearly showed that the role of science teachers is higher in Finnish schools than in the Frankfurt school (table 7, table 8), and that the role of parents is smaller in Finland than in Germany. Also it can be noted that environmental organisations, Greenpeace and WWF, as well as movies, seem to play a bigger role in the German school than in Finnish schools. An interesting finding is also that friends seem to have as big role as an information source, both in Finland and in Germany.

TABLE 7 Comparison of the Finnish sample and the German sample with respect to the use of information sources in 1996

	Finland			Germany		
	N	Mean	%	N	Mean	%
TV and radio	335	5.23	65.4 %	193	4.91	61.4 %
Science teacher	335	4.39	54.8 %	193	3.76	47.0 %
Newspaper or magazine	335	3.49	43.6 %	193	3.04	38.0 %
Parents	335	1.96	24.5 %	193	2.45	30.6 %
Other teacher	335	1.11	13.8 %	193	1.54	19.3 %
Greenpeace or WWF	335	1.07	13.3 %	193	1.41	17.6 %
Friends	335	0.87	10.9 %	193	1.21	15.1 %
Movies	335	0.86	10.8 %	193	1.06	13.3 %
Conservation organisation	335	0.73	9.2 %	193	1.06	13.3 %
Consumer organisation	335	0.49	6.1 %	193	0.55	6.9 %
Municipality	335	0.48	6.0 %	193	0.51	6.4 %

The differences between the pupils of the two countries were tested using the chi-squared method. The tests show that there are significant differences with respect to the role of science teachers, movies and Greenpeace/WWF, but to a lesser extent when parents are concerned (table 8).

TABLE 8 Differences between Finnish and German pupils' information sources in 1996

	Chi-Squared tests	Fin/Ger	
	Value	df	p
Science teacher	20.68	4	0.00
Parents	7.71	4	0.10
Greenpeace/WWF	25.77	4	0.00
Movies	24.89	4	0.00

The 2000 study

When the answers of the 2000 questionnaire were analysed, some very clear differences between Finnish and German pupils could be found.

TV, radio and newspapers and especially parents seem to be more important sources of information in Germany than in Finland (table 9), hence Finnish pupils mention their science teacher and the Internet more often than do the German pupils. So this study reveals that overall the role of the science teacher is more important in Finnish schools than it seems to be in German schools, according to this sample of Frankfurt pupils.

TABLE 9 Comparison of the Finnish sample and the German sample with respect to the use of information sources in 2000

	Finland			Germany		
Finland /Frankfurt	N	Mean	%	N	Mean	%
TV and radio	301	4.31	53.9 %	48	4.81	60.2 %
Science teacher	301	4.19	52.4 %	48	3.06	38.3 %
Newspaper	301	2.47	30.9 %	48	3.21	40.1 %
Parents	301	1.40	17.5 %	48	3.32	41.5 %
Other teacher	301	1.06	13.3 %	48	1.33	16.7 %
Internet	301	0.81	10.1 %	48	0.60	7.6 %
Movies	301	0.72	9.0 %	48	1.08	13.5 %
Friends	301	0.67	8.3 %	-	-	-
Conservation organisation	301	0.65	8.1 %	48	0.52	6.5 %
Greenpeace or WWF	301	0.63	7.8 %	48	1.29	16.1 %
Municipalities	301	0.49	6.1 %	48	0.50	6.3 %
Consumer organisation	301	0.34	4.2 %	48	0.27	3.4 %

The results confirm three of the earlier found differences between Finnish and German pupils: Finnish pupils obtain environmental information significantly more often from science teachers and German pupils from their parents and from Greenpeace or WWF. Also newspapers as an information source seem to have a bigger role among pupils in Frankfurt than among pupils in Finland, but the difference is not statistically significant (table 10).

TABLE 10 Differences between Finnish and German pupils' information sources in 2000

	Chi-Squared tests Fin/Ger		
	Value	df	p
Science teacher	20.20	4	0.00
Parents	44.35	4	0.00
Greenpeace/WWF	13.02	4	0.01
Newspapers	6.20	4	0.18
Other teacher	8.10	4	0.09

It seems that the Internet is more used in Finland to find environmental information than in Germany. However, because of the small number of German pupils in the 2000 study, the difference is within the error margins.

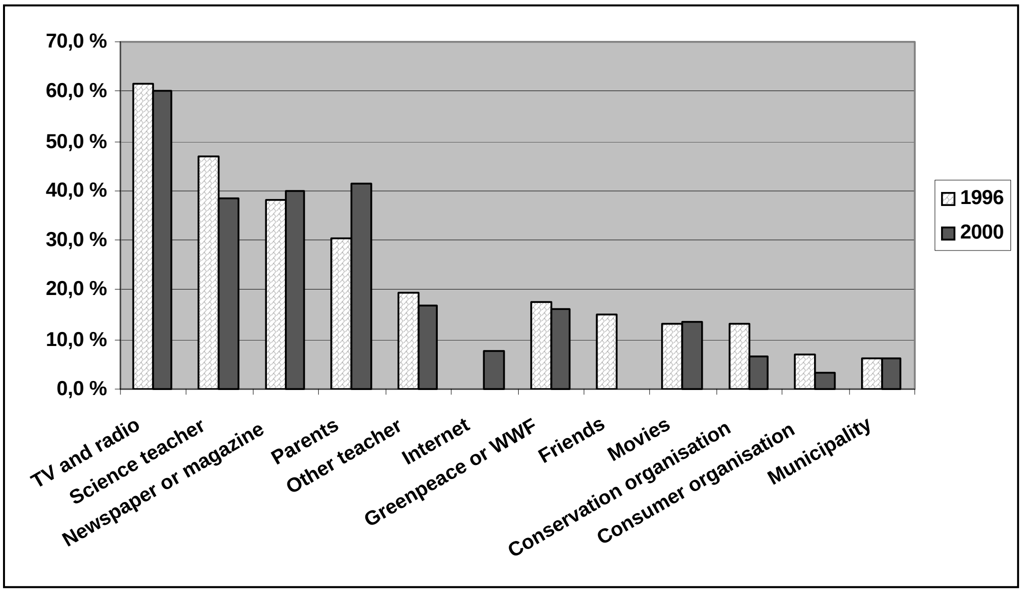


FIGURE 10 Information sources of Frankfurt pupils. (Friends as an information source was accidentally omitted from the German 2000 questionnaire)

7.1.3 Are there gender differences with regard to sources of information?

The 1996 study

Boys get more environmental information from television and the movies compared to girls, who in turn get more information from their parents and science teachers (table 11). Other sources seem to have almost equally important roles as information sources for both boys and girls.

The statistically significant gender differences can be seen in table 12 in the case of TV and radio, movies, parents and science teachers as information sources.

TABLE 11 Information sources of boys and girls of the Frankfurt and Finnish schools

	Gender	N	Mean	%
TV and radio	Female	261	4.72	59.1 %
	Male	266	5.49	68.6 %
Newspaper	Female	261	3.16	39.5 %
	Male	266	3.48	43.5 %
Movies	Female	261	0.79	9.8 %
	Male	266	1.17	14.6 %
Friends	Female	261	1.13	14.2 %
	Male	266	0.99	12.4 %
Science teacher	Female	261	4.31	53.9 %
	Male	266	4.00	50.0 %
Other teacher	Female	261	1.15	14.3 %
	Male	266	1.13	14.1 %
Parents	Female	261	2.50	31.2 %
	Male	266	1.78	22.2 %
Greenpeace/WWF	Female	261	0.98	12.2 %
	Male	266	1.24	15.6 %
Conservation organisation	Female	261	0.88	11.0 %
	Male	266	1.00	12.5 %
Consumer organisation	Female	261	0.45	5.6 %
	Male	266	0.58	7.2 %
Municipality	Female	261	0.44	5.5 %
	Male	266	0.55	6.9 %

TABLE 12 Statistically significant gender differences with respect to information sources (N = 527)

	Chi-squared/ gender	
	Value	p
Tv and radio	28.57	0.00
Movies	9.91	0.04
Parents	22.61	0.00
Science teacher	14.24	0.01

When the gender differences of the two countries were studied separately, it turned out that the differences in Frankfurt were greater than in Finland, where only TV and radio as an information source was clearly different for girls and boys, i.e. the boys got a lot more information from television than the girls.

The 2000 study

The study made in 2000 shows that the use of TV and radio as information sources has dropped for boys in both countries. At the same time boys seem to have replaced the science teacher, at least partly, with the Internet as a source of environmental information. With the Finnish girls, on the contrary, the role of the science teacher seems to be slightly stronger than five years earlier. The difference (2.6%-units) is, however, within the error margins. With the German pupils the small sample in 2000 makes comparisons between the years more difficult.

For the Finnish boys the two main information sources were TV and radio and the science teacher. For the girls the sources are same, but the order of importance is different. The difference between boys and girls, as far as the science teacher as an information source is concerned, is significant ($p < 0.01$). On the other hand, the difference in the rating of TV and radio that was found in 1996 has almost disappeared. The girls now use TV and radio practically as much as boys (table 13).

In 1996 in Germany, TV and radio were the main information sources, followed by science teachers. The confidence intervals of the German numbers for 2000 are large and the order of importance is not sure. Parents have an important role in Germany and it seems to have grown from 1996 to 2000.

TABLE 13 The information sources of pupils in 1996-2000 by country and gender

gender		Fin96	Fin00	Ger96	Ger00
Female	TV and Radio	61.0 %	52.8 %	55.7 %	63.0 %
	Newspaper	43.2 %	32.4 %	33.2 %	35.9 %
	Movies	8.7 %	8.2 %	11.7 %	11.5 %
	Friends	14.3 %	8.6 %	13.9 %	
	Science teacher	57.9 %	60.8 %	47.0 %	44.3 %
	Other teacher	14.2 %	14.1 %	14.6 %	16.1 %
	Parents	28.8 %	19.4 %	35.4 %	50.0 %
	Greenpeace or WWF	11.2 %	9.4 %	13.9 %	13.5 %
	Conservation organisation	11.8 %	11.0 %	9.6 %	4.2 %
	Consumer organisation	5.7 %	3.5 %	5.5 %	2.1 %
	Municipality	5.5 %	5.6 %	5.3 %	6.8 %
	Internet		8.6 %		2.6 %
	Does not know the source	6.9 %	5.7 %	6.1 %	9.2 %
	Does not know the concept	6.1 %	8.7 %	3.8 %	3.1 %
Male	TV and Radio	69.6 %	54.8 %	66.8 %	58.2 %
	Newspaper	44.0 %	29.5 %	42.4 %	45.1 %
	Movies	9.6 %	9.7 %	23.4 %	14.7 %
	Friends	12.4 %	8.1 %	12.5 %	
	Science teacher	51.8 %	44.9 %	46.7 %	31.5 %
	Other teacher	13.5 %	12.6 %	15.1 %	17.4 %
	Parents	20.3 %	15.9 %	25.7 %	33.7 %
	Greenpeace or WWF	10.4 %	6.5 %	24.7 %	18.5 %
	Conservation organisation	10.0 %	5.6 %	17.1 %	8.7 %
	Consumer organisation	6.5 %	4.8 %	8.5 %	3.8 %
	Municipality	6.5 %	6.5 %	7.6 %	5.4 %
	Internet		11.5 %		12.0 %
	Does not know the source	9.6 %	9.2 %	8.2 %	8.2 %
	Does not know the concept	5.5 %	5.2 %	2.3 %	3.8 %

Newspapers and magazines are important information sources in both countries. Boys in Finland, however, found less environmental information in newspapers in 2000 than four years earlier, possibly because of enhanced use of Internet.

However, as mentioned earlier, the formed variables are not necessarily normally distributed and that is why the possible differences were also studied using chi-squared method. The chi-squared method reveals that there is indeed a significant difference between Finnish boys and girls with respect to science teachers as information sources: the girls more often get their information from science teachers than the boys (table 14).

TABLE 14 The role of science teachers as sources of environmental information by gender of pupils (the numbers at the head of each column indicate the number of environmental matters marked by pupils)

Science teachers as information sources			The amount of environmental issues marked by pupils					Total
			0	1-2	3-4	5-6	7-8	
Gender	Female	N	14	20	24	28	55	141
		%	9.9%	14.2%	17.0%	19.9%	39.0%	100.0%
	Male	N	37	35	21	27	40	160
		%	23.1%	21.9%	13.1%	16.9%	25.0%	100.0%
Total		N	51	55	45	55	95	301
		%	16.9%	18.3%	15.0%	18.3%	31.6%	100.0%

It is interesting to notice that the gender difference measured using the chi-squared method is significant (p=0.003)

7.1.4 Are there differences between age groups in respect of the sources of information?

The 1996 study

It is expected that the amount of environmental information accumulates over the years and that is why the class grade of a pupil should correlate with the number of marks he has made on the questionnaire.

The results show that the strongest positive correlation is with the class grade and the amount of information from the science teachers (table 15). Also the older pupils more often mention TV and radio as the information source but more often forget parents compared to the younger ones. The other correlations are not significant, except the obvious ones: the amount of “do not know where” and “unknown concept”-answers reduces with age.

The above mentioned significant correlations (table 15) are due to the Finnish pupils. When pupils from Frankfurt were studied, no significant correlations between class grades and information sources could be found. With

Finnish pupils, however, Spearman's correlation coefficient between class grade and importance of science teachers as information source is as high as 0.436.

In the 2000 study, a clear correlation is seen between the class grade of the pupils and the use of the information sources (table 16).

The result confirms the earlier 1996 findings that the importance of TV and radio, and especially the science teachers, as an information source, increases as the pupils grow older. The same is also true of the Internet, which was not studied earlier. Also the role of the municipalities grows with the age of pupils. The enhanced importance of the municipalities is not as clear as the others mentioned, because the same phenomena could not be found in the 1996 study and, on the other hand, their role as information sources is small. The change might be due to more frequent distribution of information on municipal recycling rules which took place at the end of the1990s, as the result of the Finnish waste act, (Suomen jätelaki/Finnish waste act, 1993) and which might have been noticed by the older pupils.

TABLE 15 Correlation of the use of information sources with the class grade in year 1996 study (N = 528)

	SPEARMAN	
	Corr. Coefficient	p
TV and radio	0.12	0.01
Newspaper	0.07	0.08
Movies	-0.02	0.71
Friends	0.03	0.54
Science teacher	0.29	0.00
Other teacher	-0.00	0.97
Parents	-0.10	0.02
Greenpeace or WWF	-0.04	0.39
Conservation organisation	0.03	0.46
Consumer organisation	0.05	0.28
Municipality	0.01	0.78
Does not know where	-0.12	0.01
Unknown concept	-0.20	0.00

TABLE 16 Significant correlations between the class grade of the pupils and information source in the 2000 study (N = 301)

	Spearman's rho	
	Grade	
	Correlation coefficient	p
TV and radio	0.15	0.01
Internet	0.19	0.00
Science teacher	0.35	0.00
Greenpeace or WWF	0.11	0.05
Municipalities	0.17	0.00
Unknown concept	-0.25	0.00

7.1.5 The most common information sources for different environmental concepts

When the catalytic converter was the concept studied, this research shows that 55 % of all pupils in the 1996 and 2000 samples had got information from the television and radio. The percentages of students who received information from television and radio on the other concepts were as follows: the ozone hole 77 %, acid rain 50 %, exhaust gases 73%, greenhouse effect 70 %, water pollution 79 %, harmful substances 61 % and recycling 77%.

The second most frequent information source in general seemed to be newspapers. Over 40 % of all pupils had got information on the ozone hole, exhaust gases, greenhouse effect, water pollution, harmful substances and recycling from newspapers. However, newspapers were not second in all cases. For example, in the case of acid rain only 20 % of pupils had got information from newspapers.

The third most common information source varied depending on the respondents: either parents (in case of the catalytic converter), a magazine (in the case of the ozone hole, exhaust gases or greenhouse effect), a science teacher (in case of water pollution), and some other teacher than the science teacher (in case of harmful substances and recycling). However, when all the cases were compared, the third main information source was parents.

The next most common information sources were a teacher, magazines, science teacher and some other paper. Then came e.g. friends, movies, nature conservation organisations, science magazines and schoolmates. Fewer than 10 % of pupils got their information from such sources as WWF, Greenpeace, consumer organisations or local authorities.

7.1.6 Which environmental concepts did pupils mention most often?

Recycling seems to be the most familiar environmental concept from the ones studied - at least if the familiarity is measured by the number of information sources (figure 11).

The boys had got information about the catalytic converter and acid rain from more sources than the girls. The opposite situation can be found in the case of recycling (table 17). As mentioned by Rickinson (2001, 228), this result seems to support the study of Roper Starch Worldwide (1994), which suggests that levels of factual knowledge can vary between the genders depending upon the environmental topic that is in question. His study, like this, was based on self-reported knowledge levels rather than tested levels.

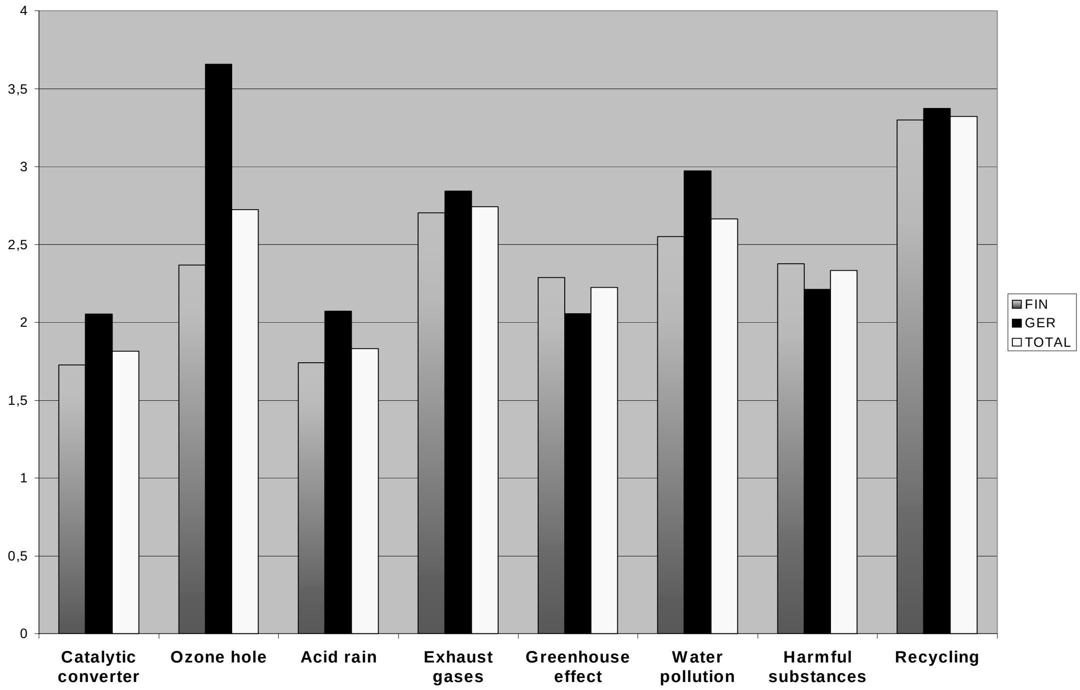


FIGURE 11 The number of information sources/pupil. The 1996 and 2000 studies combined (N=879)

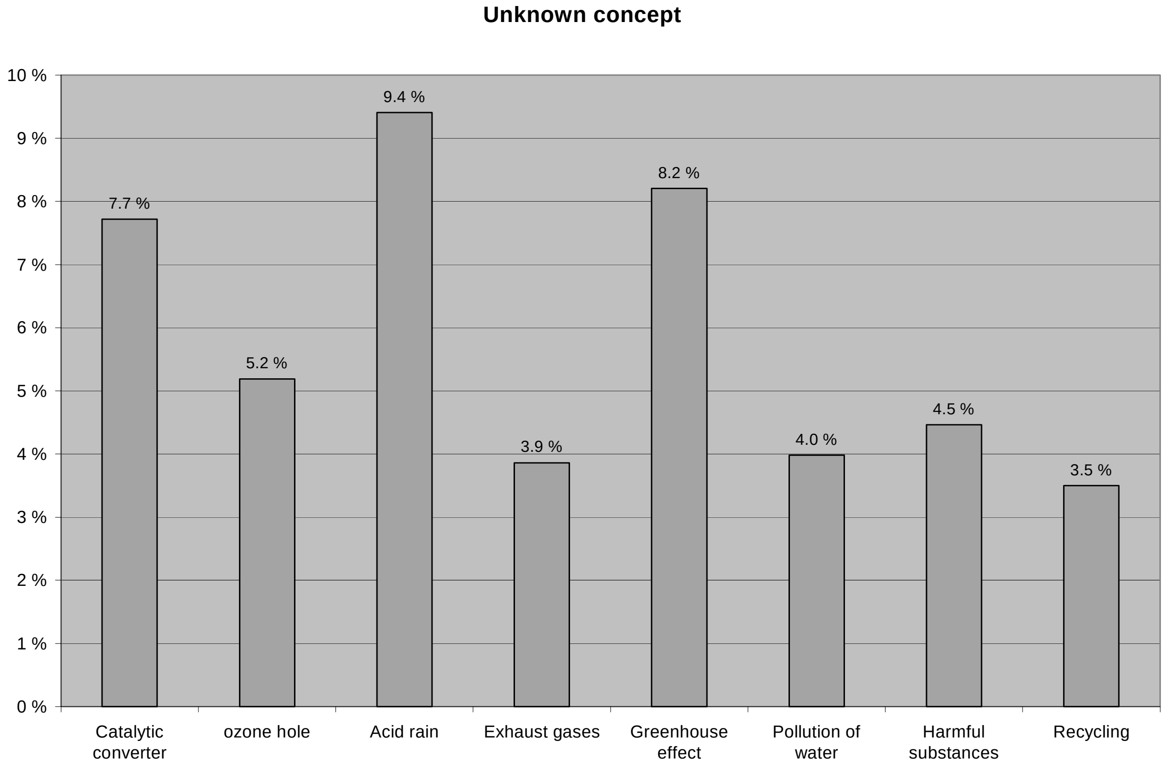
Gambro and Swittzky (1999) reported that male pupils were significantly more likely to have higher levels of environmental knowledge when compared to female pupils whereas Connell, Fien, Sykes and Yencken (1998) found that female pupils had stronger conceptual knowledge than male pupils.

TABLE 17 The confidence intervals of the average number of information sources for the eight environmental concepts by gender

	95% confidence interval of the mean					
	Female			Male		
	N	Low	high	N	low	high
Catalytic converter	402	1.41	1.71	425	1.90	2.23
Ozone hole	402	2.39	2.79	425	2.52	2.92
Acid rain	402	1.49	1.82	425	1.85	2.17
Exhaust gases	402	2.58	2.97	425	2.52	2.90
Greenhouse effect	402	2.01	2.40	425	2.07	2.42
Water pollution	402	2.63	3.05	425	2.32	2.70
Harmful compounds	402	2.17	2.56	425	2.10	2.46
Recycling	402	3.48	3.99	425	2.76	3.19

Pupils get information about recycling from numerous sources already in the 7th grade. It is the only concept where the number of information sources does not increase significantly with the age of the pupils.

When the “unknown concept” answers were compared, it was found that recycling was not recognised by only 3.5% of pupils. Acid rain is the least



known concept of the eight studied, but even that was known by over 90% of pupils. (figure 12).

FIGURE 12 Percentage of pupils unfamiliar with the mentioned environmental concepts (N = 839)

7.2 Pupils' attitudes towards environmental issues

7.2.1 The construction of the scales

As a result of the pilot study, which included 60 questions in questionnaire A, it was found that the number of questions was far too big. Pupils were not able to concentrate on answering so many questions carefully. In addition, analysis proved to be hard since the questions were not classified into any categories. Therefore, in the actual study, pupils’ attitudes towards environment and chemistry, their environmental behaviour and their confidence in environmental information was measured with a questionnaire that included 34 items in the 1996 study and 35 items in the 2000 study, where the Internet was included (appendix 1).

Five-step Likert scales (*exactly same opinion-totally different opinion* and *always-never*) were used. The coding of “negatively” stated items was reversed to make all items comparable. When positive statements like “I think that chemistry is necessary when solving environmental problems" were coded so that 1=exactly the same opinion-5=totally different opinion, negative ones like "We should not use that much money on chemical research as we do at the moment" were coded: 1=totally different opinion-5=exactly the same opinion.

Principal **C**omponent **A**nalysis (PCA) was used to find out if it is possible to form reliable scales using the chosen variables. By means of PCA the number of variables used in the scales was reduced. The chosen variables were added to form three **s**um **v**ariables SVA, SVB and SVC. The standardised values of the variables that were calculated during PCA were not used when forming the sum variables. This was done to ensure comparability of the 1996 and 2000 measurements. They were not included in the PCA.

The last two items (three in 2000) measure pupils' confidence in information sources.

7.2.2 The Principal Component Analysis

PCA was carried out for items 1-32 in questionnaire A (appendix 1) of the 1996 survey. Many of the items correlate significantly, which is a prerequisite for a factor analysis. The number of significantly correlating pairs is 297 (59.9%) and the number of pairs whose correlation coefficient exceeds 0,3 is 49 (9.9%). It is generally accepted that if no correlation exceeds 0.3 the PCA - or any Factor Analysis - is not worth doing. (Tabachnick et al. 1989, 604). The number of cases (533) is enough for the PCA, because it is more than five times the number of variables (32). (Tabachnick et al. 1989).

The highest correlation between the pairs of variables is 0.59. There is thus no multicollinearity ($r>0.9$) or singularity ($r = 1.0$) in the correlation matrix. This means that it would also be possible to use the factorial methods that invert the matrix.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy for the analysis is 0.84 that clearly exceeds the limit (0.6) for a good factor analysis. (Tabachnick et al. 1989). The component matrix after extraction of four factors and the varimax rotation with Kaiser normalisation is seen in table18. The four components explain a satisfactory 42.9% of the variance of the variables.

TABLE 18 The formation of the sub-scales from the variables b1-b32 using PCA with varimax rotation

	Rotated Component Matrix	B	A	C	D
b1	By recycling we can save resources and leave resources untouched		0.50		
b2	I think acid rain is no problem in Finland/ in Germany		0.23		0.60
b3	Old medicines should be returned to the drugstore	0.26	0.38		
b4	When our family buys washing detergent, the main criteria is that it causes as little harm to the environment as possible		0.61		
b5	The greenhouse effect will raise the temperature in our country in the future				
b6	Used chemicals should not be thrown in the sink		0.61		
b7	It is sensible to separate papers from other waste		0.58		
b8	All talk about the greenhouse effect is exaggerated		0.20		0.45
b9	It makes sense to separate waste and not just put it all in the same place	0.27	0.61		
b10	We should not send our waste to the undeveloped countries	0.27	0.24		
b11	I think that chemistry is necessary when solving environmental problems		0.37	0.51	-0.25
b12	I think the chemical industry causes more troubles than benefits		-0.28	0.57	0.20
b13	The chemical industry has an important role in solving environmental problems		0.30	0.54	-0.24
b14	A knowledge of chemistry can help when we try to minimise environmental pollution			0.50	-0.28
b15	We should not spend as much money on chemical research as we do at the moment			0.57	0.33
b16	We would be in trouble without chemistry and its applications		0.28	0.55	
b17	I think chemistry is an absolutely unnecessary science			0.60	
b18	We can often avoid using the products of the chemical industry	-0.22		0.50	0.23
b19	I think that chemical products are important			0.59	-0.30
b20	I like studying chemistry	0.51		0.32	-0.38
b21	Before throwing something away, I think whether it can be used for some other purpose.	0.65			
b22	If I am active enough, I can do a lot to save nature	0.53	0.32		
b23	I am interested to know as much as possible about environmental problems and how to solve them	0.68	0.28		
b24	I use rechargeable batteries	0.25	0.31		
b25	I think it is good that we learn more about air and water pollution at school	0.69	0.25		
b26	It is actually all the same to me what happens to the waste, the most important is to get rid of it	0.57			0.43
b27	To be honest, I am not interested in the problem of expanding amount of waste and air pollution.	0.60			0.33
b28	My behaviour has very little to do with, getting a cleaner environment	0.21			0.56
b29	A clean environment is very important for me	0.50			
b30	When I go shopping, I buy a plastic bag to take my things home		0.21		0.45
b31	I discuss environmental problems with my schoolmates	0.58			
b32	We talk about environmental problems at home	0.60			

By selecting the variables with a factor loading of at least 0.5, four Factors A, B, C and D were obtained with five, ten, nine and two variables, respectively. Factor A is called (Environmental) *Attitude* and was calculated by adding the variables b1, b4, b6, b7 and b9 to form the sum variable SVA. Factor B is called (Environmental) *Behaviour and activity.* It is described by the sum variable SVB that was formed by adding the variables b20-b23, b25-b27, b29 and b31-b32. The third factor C describes the pupils' *attitude to chemistry and the chemical industry*. The corresponding sum variable SVC was calculated by adding variables b11-b19. Factor D is more complicated to interpret than the fairly evident A, B and C. The variables with the highest factor loading give the impression that the factor consists of environmental issues that might be confusing for young pupils. The threat of acid rain is no longer as pressing as it used to be, use of plastic bags is not necessarily as harmful to nature as it was thought, etc. Factor D could be seen to measure the degree of "scepticism". Because there are only two variables in factor D, no corresponding sum variable was formed.

The variable "I like studying chemistry" was loaded on factor B instead of C, as might be expected. The variable seems to measure more the activity of the pupil than attitude to the chemical industry.

The similarly formed sum variables SVA, SVB and SVC were used to analyse the results of the 2000 survey, too. Because the values of the variables are not standardised, the two surveys can be compared without taking into account the different means and standard deviations of the results.

7.2.3 The reliability of the scales constructed

The procedure of running the same questionnaire twice gives information about the consistency of the results, but not about the reliability of the scales. Even if the pupils filling in the questionnaires had been the same in 1996 and 2000, we could not say anything about the reliability of the constructed scale by comparing the answers, because opinions change in four years, as do the features of environmental affairs. It has been suggested (Metsämuuronen 2000a) that to obtain test-retest reliability, the time difference between the tests should be as small as two weeks. The re-testing of the pupils was not possible and that is why the reliability of the scales is approached by calculating the Cronbach α coefficient (Cronbach 1951).

The values of α with its upper and lower estimates (table 19) were calculated using SPSS 10.1 and Microsoft Excel programs. The 95% confidence interval of α was obtained calculating upper and lower limits using the formula:

$$1-F_{0.975}(1-a) < \alpha < 1-F_{0.025}(1-a),$$

where $F_{0.975}$ and $F_{0.025}$ are 97.5% and 2.5% values of F-distribution with degrees of freedom df1 = n-1 and df2 = (n-1)(k-1), k = number of items in the scale, n = number of valid answers, a = calculated alpha coefficient.

The method of calculation was adopted from Metsämuuronen (2000a).

TABLE 19 The values of Cronbach α and the corresponding 95% confidence intervals.(A = environmental attitude, C= attitude towards chemistry and the chemical industry, B= environmental behaviour and activity)

1996 results				2000 results		
Scale	alpha	Lower limit	Upper limit	alpha	Lower limit	Upper limit
A	0.68	0.63	0.72	0.74	0.69	0.77
B	0.82	0.79	0.84	0.83	0.81	0.85
C	0.73	0.69	0.76	0.76	0.72	0.80

According to the results the reliability of the scales is satisfactory. None of the lower limits of α is under 0.60, which is often regarded as the lowest acceptable value. (Metsämuuronen 2000a). The alpha coefficient of the scale for environmental behaviour and activity is higher than that of the other scales. It is at least partly due to the higher number of items in the scale. Technically the value of α could be increased by using more items. In this study the pre-testing of the questionnaire showed that the young pupils are not patient enough to fill up forms containing many items. If long questionnaires are introduced, a part of the pupils will fill them in random and thus reliability will be reduced. That is why an attempt was made to minimise the size of the questionnaire.

For comparison, the alpha coefficients were calculated for the scales where all the variables b1-b32 were used, so that scale A consists of variables b1-b10, scale B of variables b21-b32 and scale C of variables b11-b20, as was planned before using Principal Component Analysis. The reliability of these scales turned out to be somewhat smaller than that of the reduced scales, despite the higher number of included variables. This is a sign of a successful choice of variables for the reduced scales.

The item-total correlation within the scales is quite high, taking into account the large sample sizes. (tables 20-22)

TABLE 20 Item-total correlation of the scale "environmental attitude" (N = 527 in 1996 and N=335 in 2000)

	Spearman's rho	
	1996	2000
It makes sense to separate waste and not just put it all in the same place	0.68	0.75
When our family buys washing detergent the main criteria is that it causes as little harm to the environment as possible	0.71	0.72
It is sensible to separate papers from the other waste	0.61	0.73
By recycling we can save resources and leave resources untouched	0.59	0.48
Used chemicals should not be thrown in the sink	0.55	0.65

The inter-item correlations with the variables in scale A are all very significant and vary from 0.166 to 0.710. The inter-item correlation is high compared to the average correlation (0.138) for all pairs of variables in the scales.

TABLE 21 Item-total correlation of the scale "environmental behaviour and activity" (N = 527 in 1996 and N=331 in 2000)

	Spearman's rho	
	1996	2000
I am interested to know as much as possible about environmental problems and how to solve them	0.75	0.73
I think it is good that we learn more about air and water pollution at school	0.71	0.70
It is actually all the same to me what happens to the waste, the most important is to get rid of it	0.67	0.72
To be honest, I am not interested in the problem of expanding amount of waste and air pollution	0.67	0.74
We talk about environmental problems at home	0.63	0.60
Before throwing something away, I think over whether it can be used for some other purpose.	0.67	0.60
I discuss environmental problems with my schoolmates	0.58	0.60
If I am active enough, I can do a lot to save the nature	0.56	0.68
A clean environment is very important for me	0.51	0.57
I like studying chemistry	0.34	0.29

The item-total correlations are all very significant, even for the variable "I like studying chemistry" that correlates clearly less with the sum variable SVB than the other variables. The inter-scale correlations vary from 0.058 to 0.717 and with one exception are higher than the average correlation between the pairs of the used variables.

TABLE 22 Item-total correlation of the scale "attitude towards chemistry" (N = 527 in 1996 and N=331 in 2000)

	Spearman's rho	
	1996	2000
I think chemistry is an absolutely unnecessary science	0.59	0.69
We would be in trouble without chemistry and its applications	0.58	0.60
The chemical industry has an important role in solving environmental problems	0.57	0.51
I think that chemical products are important	0.57	0.59
I think that chemistry is necessary when solving environmental problems	0.56	0.49
A knowledge of chemistry can help when we try to minimise environmental pollution	0.54	0.57
We should not spend as much money on chemical research as we do at the moment	0.52	0.54
I think the chemical industry causes more troubles than benefits	0.48	0.56
We can often avoid using the products of the chemical industry	0.48	0.54

The item-total correlation is not as high as with scales A and B, but still the correlations are very significant and they are all quite close to each other. The range of the inter-scale correlation coefficients is from 0.030 to 0.457 with four coefficients below the average correlation between all variables (0.138).

With all three formed scales A, B and C, the correlation within the scales is systematically higher than correlation between the variables from different scales. This is a sign of the construct validity of the scales. (Metsämuuronen 2000a)

7.2.4 The distributions of the sum variables

The distributions of the **s**um **v**ariables SVA, SVB and SVC mentioned earlier are quite symmetric, with medians close to means and quartiles almost evenly situated on both sides of the medians (table 23). The distributions are rather close to normal (figure 13). Together with the relatively large sample sizes, this means that using the analysis of variance (ANOVA) on the sum variables is possible. (Metsämuuronen 2000b).

To make sure that the results are correct, the results were double-checked using a more robust non-parametric method, Kruskal-Wallis tests. The K-W test gave similar results to the ANOVA. Only the results of ANOVA are presented.

When comparing the values of the sum variables for different groups, it must be taken into account that the scales were formed in such a way that the smaller the value is, the more positive the attitude (opinion and behaviour) is.

TABLE 23 The means, standard deviations and quartiles of the sum variables

		Year 1996			Year 2000		
		SVA	SVB	SVC	SVA	SVB	SVC
N	Valid	528	528	527	341	337	331
Mean		9.0	23.3	22.8	10.0	26.9	23.5
Median		9.0	23.0	23.0	9.0	27.0	23.0
Std. Deviation		3.0	6.1	5.1	3.5	6.6	5.6
Percentiles	25	7.0	19.0	20.0	8.0	22.0	20.0
	75	10.0	27.0	26.0	12.0	32.0	27.0

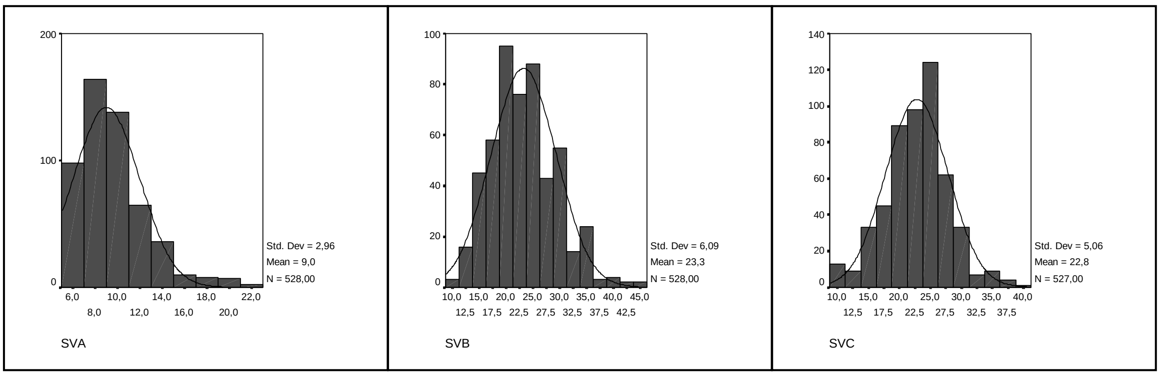


FIGURE 13 The distributions of the sum variable SVA, SVB and SVC (1996)

7.2.5 Environmental attitudes

To be able to compare the environmental attitudes of different groups, the sum variable SVA was studied using univariate variance analysis. Gender, class grade and country of the pupils were used as fixed factors and SVA was studied as dependent variable (table 24). Also the covariation of gender and country, gender and class grade, and country and class grade were studied.

1996 results

TABLE 24 The analysis of variance of the sum variable SVA, general environmental attitudes

Source	df	Mean Square	F	p.
Gender	1	120.74	15.87	0.00
Country	1	318.01	41.79	0.00
Class grade	2	22.54	2.96	0.05
Gender*country	1	48.16	6.33	0.01
Gender*class grade	2	4.77	0.63	0.53
Country*class grade	2	28.34	3.72	0.02

There is a significant difference between boys and girls ($p < 0.01$). Similarly there is a clear difference between the attitudes of Finnish pupils compared to the German pupils ($p<0.01$). There seems to be some differences in attitudes between different class grades, but the differences are not statistically significant (table 24).

When we look at the interaction of gender and country and of country and class grade we can see that gender differences are dissimilar in Finland and in Germany ($p = 0.01$), and differences between the class grades are also dissimilar in the two countries either ($p=0.02$), (table 24). This means that we have to take a closer look at the attitudes and study the results of the two countries separately before we can understand the differences between the different groups of pupils. This can be done by investigating the estimated marginal mean attitudes of different groups (table 25). The means and their confidence intervals, adjusted using Bonferroni method (Metsämuuronen 2000b), are collected from separate SPSS tables of the ANOVA procedure.

Attitudes of girls are more positive towards environmental questions than attitudes of boys. The difference is clear in Finland. The attitudes of German girls are most positive, but the difference to the attitudes of German boys is not significant. Also we can say that the environmental attitudes of German pupils overall are more positive than the attitudes of Finnish pupils.

The age (class grade) of the pupil affects the attitudes differently in Germany than in Finland. The attitudes of Finnish pupils get more negative from grade 7 to grade 9, but in Germany this trend cannot be seen. The attitude difference of German and Finnish pupils is not significant in the 7^{th} grade, but is significant in the 8^{th} and 9^{th} grades.

TABLE 25 The means and confidence intervals of the environmental attitude variable SVA for different groups of pupils

	Mean	95% Confidence Interval		N
		Lower Bound	Upper Bound	
Female	8.31	7.95	8.66	261
Male	9.33	8.97	9.69	267
Fin	9.66	9.36	9.95	338
Ger	7.98	7.57	8.39	190
7th grade	8.41	8.04	8.78	221
8th grade	8.95	8.48	9.42	167
9th grade	9.10	8.62	9.57	140
Fin-Female	8.83	8.40	9.25	166
Fin-Male	10.48	10.07	10.90	172
Ger-Female	7.79	7.22	8.35	95
Ger-Male	8.17	7.58	8.76	95
Female 7th grade	8.06	7.51	8.60	102
Male 7th grade	8.77	8.26	9.27	119
Female 8th grade	8.27	7.65	8.89	88
Male 8th grade	9.62	8.96	10.28	79
Female 9th grade	8.59	7.94	9.24	71
Male9th grade	9.60	8.92	10.27	69
Fin 7th grade	8.79	8.32	9.27	129
Ger 7th grade	8.03	7.46	8.60	92
Fin 8th grade	9.93	9.43	10.42	121
Ger 8th grade	7.97	7.17	8.77	46
Fin 9th grade	10.25	9.67	10.82	88
Ger 9th grade	7.94	7.19	8.70	52

2000 results

The main results of the variance analysis for the 2000 study are presented in tables 26 and 27.

TABLE 26 The analysis of variance of the sum variable SVA, general environmental attitudes, the 2000 study

Source	df	Mean Square	F	p
Gender	1	38.59	3.38	0.07
Country	1	55.53	4.86	0.03
Class grade	2	21.75	1.90	0.15
Gender*country	1	3.41	0.30	0.59
Gender*class grade	2	24.74	2.17	0.12

TABLE 27 Means and confidence intervals of the environmental attitude variable SVA for different groups of pupils

	Mean	95% Confidence Interval		N
		Lower Bound	Upper Bound	
Female	9.27	8.71	9.83	160
Male	10.45	9.92	10.98	180
Fin	10.18	9.79	10.58	294
Ger	8.88	7.90	9.87	46
7th grade	9.68	8.99	10.38	91
8th grade	9.53	8.95	10.11	164
9th grade	10.69	9.95	11.42	85
Fin-Female	9.78	9.20	10.36	138
Fin-Male	10.59	10.05	11.12	156
Ger-Female	7.73	6.31	9.15	22
Ger-Male	10.04	8.68	11.40	24
Female 7th grade	9.82	8.83	10.81	45
Male 7th grade	9.54	8.56	10.52	16
Female 8th grade	8.54	7.70	9.37	80
Male 8th grade	10.53	9.73	11.33	84
Female 9th grade	10.17	9.05	11.30	35
Male9th grade	11.20	10.26	12.14	50

There is still a clear difference between the environmental attitudes of Finnish and German pupils, but the small number of German pupils in the sample makes comparison more difficult than in the 1996 study. The gender difference is also present, as in 1996, but the difference is smaller because the attitudes of Finnish girls are clearly more negative in 2000 than in 1996 and thus closer to the attitudes of the Finnish boys.

The covariation of the country and class grade could not be studied in the latter survey, because all German pupils were 8th graders (actually 9th grade in Germany). For the Finnish pupils the environmental attitudes take a more negative direction as the age of the pupils increases. The change is not, however, statistically significant.

There is an overall trend for environmental attitudes to move in a more negative direction from 1996 to 2000. Especially the attitudes of Finnish girls are more negative in the latter sample. (tables 25 and 27). A similar change is seen in the attitudes of German boys, too, but the small sample in 2000 in Frankfurt makes the confidence interval of the German numbers very large.

7.2.6 Attitudes towards chemistry and the chemical industry

The sum variable SVC was formed by combining the nine variables b11-b19, as described above to measure the pupils' attitudes towards chemistry and the chemical industry. The range of the variable is from 9 to 45 points. The values describing the distribution of the variable are in table 23.

Similarly to the variable SVA, the sum variable SVC was studied using univariate variance analysis. Gender, class grade and country of pupils were used as fixed factors and SVC was studied as a dependent variable.

1996 results

The results of the variance analysis and the estimated marginal means for the different groups of pupils are presented in tables 28 and 29.

TABLE 28 Variance analysis of the variable SVC, attitudes towards chemistry and the chemical industry

Source	df	Mean Square	F	p
Gender	1	261.47	10.82	0.00
Country	1	184.93	7.65	0.01
Class grade	2	58.48	2.42	0.09
Gender*country	1	402.54	16.66	0.00
Gender*class grade	2	50.16	2.08	0.13
Country*class grade	2	133.30	5.52	0.00

There is a gender-based difference in the attitudes towards chemistry. Attitudes of girls are more negative than attitudes of boys. Also we can find that the attitudes of German pupils are more positive to chemistry and the chemical industry than the attitudes of Finnish pupils (table 29).

The gender difference is mainly due to the German pupils. For Finnish pupils there is no significant difference with respect to gender, but German boys are far more positive towards chemistry than girls (table 29).

The positive attitudes of German boys also cause the difference between the pupils of the two countries. The attitudes of Finnish pupils and German female pupils are close to each other, but the attitudes of German boys are very positive, compared to the other groups.

The gender and country based differences in attitudes seem to increase with the age of the pupils. The significant differences appear in pupils in the 9th grade (table 29).

TABLE 29 Means and confidence intervals of the variable SVC for different groups of pupils

	Mean	95% confidence interval		N
		Lower Bound	Upper Bound	
Female	23.30	22.67	23.93	262
Male	21.80	21.15	22.44	265
Fin	23.19	22.65	23.72	338
Ger	21.91	21.17	22.64	189
7th grade	23.12	22.46	23.78	220
8th grade	22.60	21.77	23.44	167
9th grade	21.92	21.07	22.77	140
Fin-Female	23.02	22.26	23.78	166
Fin-Male	23.36	22.61	24.10	172
Ger-Female	23.58	22.58	24.58	96
Ger-Male	20.24	19.19	21.29	93
Female-7th grade	23.34	22.38	24.30	103
Male-7th grade	22.91	22.00	23.81	117
Female-8th grade	23.34	22.24	24.45	88
Male-8th grade	21.87	20.69	23.04	79
Female-9th grade	23.22	22.06	24.38	71
Male-9th grade	20.62	19.42	21.83	69
Fin-7th grade	23.10	22.25	23.95	129
Ger-7th grade	23.14	22.13	24.16	91
Fin-8th grade	22.81	21.93	23.69	121
Ger-8th grade	22.40	20.97	23.83	46
Fin-9th grade	23.65	22.62	24.68	88
Ger-9th grade	20.19	18.84	21.53	52

2000 results

The 1996 results were compared to the 2000 results by carrying out a corresponding variance analysis. The results for 2000 are presented in tables 30 and 31.

The German pupils were all from the same class grade and the country-class grade effect could not be examined in the latter study. The small number of German pupils (N = 46) affects the corresponding confidence intervals of the estimated means and may thus conceal possible differences between the groups.

TABLE 30 Variance analysis of the sum variable SVC, the 2000 study

Source	df	Mean Square	F	p.
Gender	1	39.36	1.34	0.25
Country	1	270.90	9.26	0.00
Class grade	2	32.41	1.11	0.33
Gender*country	1	5.28	0.18	0.67
Gender*class grade	2	121.39	4.15	0.02

TABLE 31 Means and confidence intervals of the variable SVC for different groups of pupils in the 2000 study

	Mean	95% Confidence Interval		N
		Lower Bound	Upper Bound	
Female	24.04	23.13	24.94	155
Male	22.49	21.64	23.34	176
Fin	24.03	23.38	24.67	285
Ger	20.98	19.41	22.55	46
7th grade	24.72	23.55	25.88	83
8th grade	22.41	21.48	23.34	163
9th grade	23.51	22.34	24.69	85
Fin-Female	24.40	23.46	25.34	133
Fin-Male	23.65	22.78	24.52	152
Ger-Female	22.96	20.69	25.22	22
Ger-Male	19.00	16.83	21.17	24
Female-7th grade	24.15	22.48	25.81	41
Male-7th grade	25.29	23.64	26.93	42
Female-8th grade	24.19	22.85	25.52	79
Male-8th grade	20.63	19.35	21.92	84
Female-9th grade	23.63	21.83	25.43	35
Male-9th grade	23.40	21.89	24.91	50

There is still a difference in the attitudes of boys with respect to the attitudes of girls towards chemistry and the chemical industry. The boys tend to be more positive towards chemistry and the chemical industry than girls. The difference of the mean attitudes of boys and girls has increased from 1996 to 2000. The increase is caused by the attitude change of Finnish pupils. In Finland the boys now also have more positive attitudes than girls. Because of the smaller sample in the 2000 study the differences are not, however, statistically significant.

The attitudes of German pupils are clearly more positive compared to Finnish pupils. This is the case especially with the German boys. Their positive attitudes also explain the gender-based difference with the 8th grade pupils (all the German pupils were in the 8th grade).

When we look at the individual questions (table 32), we see that in Germany the mean of the boys' answers is lower for each item compared to the mean of the girls. In Finland there are no significant differences between boys and girls in this respect in 1996, but in 2000 the situation has changed. The attitudes of the Finnish girls have turned more negative with respect to chemistry and the chemical industry. The variable “I like studying chemistry” is also included, though it is not included in sum variable SVC.

The most striking result seen in table 32 is the general negative attitude toward studying chemistry. Especially German pupils, whose attitudes are in general more positive than those of the Finnish pupils, do not like to study chemistry. This is the case also with the German boys, who are otherwise most favourable to chemistry and the chemical industry.

When looking at the results in table 32, it must be taken into account that the error margins of the means are about 0.2 units (95% confidence interval). This means that smaller margins than 0.4 units between the means do not necessarily mean a significant difference between them. In the German figures the error margin in 2000 is even larger (from 0.3 to 0.6) because of the small sample size.

TABLE 32 The means of the variables dealing with chemistry and the chemical industry by year, country and gender

	Fin 1996		Fin 2000		Ger 1996		Ger 2000	
	girl	boy	girl	boy	girl	boy	girl	boy
I think that chemistry is necessary when solving environmental problems	2.37	2.62	2.74	2.43	2.42	2.32	3.00	2.33
I think the chemical industry causes more troubles than benefits	3.13	3.03	3.26	2.89	3.25	2.97	2.92	2.38
The chemical industry has an important role in solving environmental problems	2.51	2.52	2.79	2.59	2.47	2.29	2.88	2.42
A knowledge of chemistry can help when we try to minimise environmental pollution	2.02	2.05	2.15	2.27	2.60	2.16	2.75	2.04
We should not spend as much money on chemical research as we do at the moment	3.02	3.08	3.11	3.03	3.00	2.72	2.78	2.42
We would be in trouble without chemistry and its applications	2.49	2.53	2.55	2.41	2.35	2.03	2.29	1.92
I think chemistry is an absolutely unnecessary science	1.78	2.01	2.28	2.37	1.81	1.48	1.76	1.29
We can often avoid using the products of the chemical industry	3.02	3.01	2.97	3.22	2.64	2.32	2.67	2.08
I think that chemical products are important	2.57	2.55	2.58	2.41	3.09	2.51	2.80	2.13
I like studying chemistry	2.80	2.80	3.65	2.96	4.42	3.99	4.50	3.50

Between 1996 and 2000, the attitude of the Finnish girls to studying chemistry has taken a much more negative direction. In 2000 only about one fifth of the Finnish girls expressed the opinion, either exactly or partly: “I like studying chemistry”. At the same time the attitudes of Finnish boys seem to have taken a slightly negative direction, too, but because of the error margins (about 7.5%-units) we cannot be sure about this change (table 33).

TABLE 33 The percentage of pupils who have exactly or partly the opinion: "I like studying chemistry"

"I like studying chemistry"	At least partly agree				
	Finnish female	Finnish male	German female	German male	Total
Year 1996	48.8%	46.5%	7.2%	8.5%	33.3%
Year 2000	20.9%	41.9%	4.2%*	20.8%*	29.3%
Valid N 1996	166	172	97	94	529
Valid N 2000	139	160	24	24	347
* The number may be misleading because of the small sample					

The small numbers of German girls and boys in the 2000 sample make it impossible to compare the German percentages between 1996 and 2000. Only thing that can be deduced from the German percentages is that Finnish pupils still like studying chemistry more than their counterparts from one particular school in Frankfurt.

7.2.7 Environmental activity and behaviour

The variable group B, *environmental activity and behaviour*, consisted of 10 items that were added together to form a sum variable SVB with a theoretical range from 10 to 50. The variable was studied using variance analysis, similarly to the other two sum variables SVA and SVC.

1996 results

TABLE 34 Variance analysis of the sum variable SVB, the 1996 study

Source	df	Mean Square	F	p
Gender	**1**	976.87	29.22	0.00
Country	**1**	200.82	6.01	0.01
Class grade	**2**	33.30	1.00	0.37
Gender*country	**1**	419.38	12.54	0.00
Gender*class grade	**2**	14.88	0.45	0.64
Country*class grade	**2**	7.80	0.23	0.79

The environmental activity and behaviour of girls and boys differ similarly to the variables studied earlier. Again we can say that the opinions and behaviour of the girls are more favourable to the environment than those of the boys (table 35). However, in Frankfurt the difference between boys and girls is not significant, but in Finnish schools girls' self-reported behaviour is clearly more positive compared to the boys' behaviour and also to the German pupils' behaviour.

It is worth noting that the same gender-based difference can be found in all class levels from 7th to 9th grade, but the total means of the class grades do not differ significantly (table 35).

TABLE 35 Means and confidence intervals of the variable SVB for different groups of pupils in the 1996

	Mean	95% Confidence Interval		N
		Lower Bound	Upper Bound	
Female	22.01	21.27	22.75	262
Male	24.91	24.15	25.67	266
Fin	22.80	22.17	23.42	338
Ger	24.13	23.26	24.99	190
7th grade	23.16	22.38	23.94	221
8th grade	24.01	23.03	25.00	167
9th grade	23.21	22.22	24.21	140
Fin-Female	20.41	19.51	21.30	166
Fin-Male	25.19	24.31	26.06	172
Ger-Female	23.62	22.44	24.80	96
Ger-Male	24.64	23.41	25.87	94
Female-7th grade	22.03	20.89	23.16	103
Male-7th grade	24.30	23.24	25.35	118
Female-8th grade	22.35	21.05	23.65	88
Male-8th grade	25.68	24.29	27.06	79
Female-9th grade	21.66	20.30	23.03	71
Male-9th grade	24.77	23.35	26.18	69
Fin-7th grade	22.28	21.27	23.28	129
Ger-7th grade	24.05	22.86	25.24	92
Fin-8th grade	23.36	22.32	24.39	121
Ger-8th grade	24.67	22.99	26.35	46
Fin-9th grade	22.76	21.55	23.97	88
Ger-9th grade	23.67	22.09	25.25	52

2000 results

The striking difference between the self-reported environmental activity and behaviour of Finnish girls and boys that was found in 1996 has changed somewhat during the four years. The significant difference still exists, but also the behaviour of Finnish girls has become more negative (tables 36 and 37).

TABLE 36 Variance analysis of the sum variable SVB, the 2000 study

Source	df	Mean Square	F	p
Gender	1	229.36	5.62	0.02
Country	1	346.51	8.49	0.00
Class grade	2	15.84	0.39	0.68
Gender*country	1	4.33	0.11	0.74
Gender*class grade	2	19.72	0.48	0.62

TABLE 37 Means and confidence intervals of the variable SVB for different groups of pupils in the 2000 study

	Mean	95% Confidence Interval		N
		Lower Bound	Upper Bound	
Female	25.78	24.73	26.83	159
Male	28.45	27.46	29.45	177
Fin	26.25	25.50	27.00	288
Ger	29.73	27.92	31.54	48
7th grade	26.44	25.10	27.79	88
8th grade	28.13	27.05	29.21	164
9th grade	25.76	24.37	27.15	84
Fin-Female	24.71	23.60	25.81	135
Fin-Male	27.79	26.77	28.81	153
Ger-Female	29.00	26.43	31.57	24
Ger-Male	30.46	27.89	33.02	24
Female-7th grade	24.48	22.54	26.42	42
Male-7th grade	28.41	26.56	30.27	46
Female-8th grade	27.22	25.70	28.75	82
Male-8th grade	29.04	27.51	30.56	82
Female-9th grade	24.20	22.08	26.32	35
Male-9th grade	27.33	25.53	29.12	49

There is a significant difference between the opinions and behaviour of the Finnish sample of pupils and Frankfurt pupils, with the Finnish pupils reporting more positive environmental activity and behaviour than the German pupils. There are no significant differences between the class grades.

In 2000 the environmental behaviour of all gender/country groups is clearly more negative than four years earlier. Even when the large confidence intervals for German means in 2000 are taken into account the negative change is significant (tables 35 and 37). There is every justification for the statement that the pupils’ opinions about environmental questions have taken a more negative direction - at least if positivity/negativity is estimated with the scale used in this study. There is no doubt that environmental problems, such as several oil tankers spilling oil or medical companies polluting rivers in Europe as well as some environmentally dangerous chemicals contaminating nature, have a negative effect on pupils' attitudes towards the chemical industry.

To see which statements have most influenced this trend, all the ten items in the scale are studied separately (table 38).

TABLE 38 The means of the statements of the sum variable SVB by year, country and gender

	Fin 1996		Fin 2000		Ger 1996		Ger 2000	
	girl	boy	girl	boy	girl	boy	girl	boy
I like studying chemistry	2.80	2.80	3.65	2.96	4.42	3.99	4.50	3.50
Before throwing something away, I think whether it can be used for some other purpose.	2.36	2.73	2.65	3.03	2.90	2.93	3.25	3.71
If I am active enough, I can do a lot to save nature	1.74	2.09	1.99	2.53	2.29	2.28	2.92	3.17
I am interested to know as much as possible about environmental problems and how to solve them	2.38	3.19	3.15	3.31	2.59	2.84	3.20	3.50
I think it is good that we learn more about air and water pollution at school	1.98	2.40	2.64	2.83	2.81	2.57	3.40	3.50
It is actually all the same to me what happens to waste, the most important thing is to get rid of it	1.63	2.42	2.20	2.81	1.70	2.14	2.71	3.00
To be honest I am not interested in the increasing amount of waste and air pollution	1.52	2.31	2.09	2.67	1.80	2.18	2.44	2.63
A clean environment is very important for me	1.31	1.66	1.71	1.99	1.80	1.67	2.28	2.13
I discuss environmental problems with my schoolmates	3.80	4.27	4.19	4.39	4.01	4.14	4.52	4.58
We talk about environmental problems at home	3.72	4.07	4.11	4.28	3.70	3.76	4.00	4.25

All the other changes from 1996 to 2000 are negative, except that the German boys like to study chemistry a little bit more in the latter survey. It can be noted, for example, that the pupils care less about what happens to waste than four years earlier and also that they want to learn less about pollution at school. As mentioned earlier, Finnish girls' opinions about studying chemistry have become sharply negative.

7.2.8 Differences between the Finnish schools

There were four Finnish schools where more than one hundred pupils answered the questionnaires. One school is situated in northern Finland, the others are in central Finland. One is a large suburban school two others are a large and a smaller rural school 25-40 kms from the nearest city.

Possible differences in the answers of pupils coming from different schools were studied using the Kruskall-Wallis (K-W) non-parametric test for more than two independent variables. The results show that there are no systematic differences in the answers of the pupils from different schools. In the first study in 1996 the attitudes in the large country school were more negative compared to the other schools, but in 2000 there was no school that was clearly distinguished from the others and the pupils from the same large country school had the most positive attitudes towards chemistry and the chemical industry (table 39).

TABLE 39 Kruskall-Wallis test for finding the differences between the schools with respect to the three scales SVA, SVC and SVB

		1996		2000	
	School	N	Mean Rank	N	Mean Rank
SVA	Small rural	77	171	50	158
	Large rural	85	194	133	146
	Lapland	83	169	36	149
	Suburb	92	143	75	141
	Total	337		294	
	p=	0.01		p=	0.74
SVC	Small rural	77	174	49	140
	Large rural	85	181	129	128
	Lapland	83	172	35	168
	Suburb	92	152	72	159
	Total	337		285	
	p=	0.23		p=	0.02
SVB	Small rural	77	167	48	148
	Large rural	85	195	132	146
	Lapland	83	157	36	143
	Suburb	92	157	72	140
	Total	337		288	
	p=	0.04		p=	0.95

The same results for the differences between schools were also found using a one-way ANOVA. The K-W test was selected because it is not distribution-sensitive.

One question in the questionnaire was if a pupil had taken an *environmental chemistry* course. Attending environmental teaching explains rather little of the variation of the results in different schools. The schools where a large part of pupils had attended the environmental lessons were the large country school and the suburban school. In the suburban school the environmental teaching seems to have a positive effect, but in the country school such a significant effect does not exist (table 40). This leads us to ask about the teacher’s role. Has the teacher in the suburban school succeeded better in arousing pupils’ interest in environmental questions?

TABLE 40 The effect of environmental teaching in two schools. Mann-Whitney test results

SCHOOL		SVA	SVC	SVB
Large rural	Mann-Whitney U	290	371.5	307.5
	Wilcoxon W	3140	3221.5	3157.5
	Z	-1.17	-0.05	-0.92
	p	0.24	0.96	0.36
Suburban	Mann-Whitney U	493.5	372.5	479
	Wilcoxon W	724.5	603.5	710
	Z	-1.66	-2.93	-1.80
	p	0.01	0.00	0.07
Grouping Variable: Course on environmental chemistry				

7.2.9 Believing in information

As was mentioned earlier, television is the most important media of environmental information for secondary school pupils. One question in the questionnaire was: "When we discuss environmental problems, I believe more in my teacher than the information I get from television."

It seems that most of the pupils trust in the information from TV somewhat more than they do in their teacher when environmental matters are concerned (table 41).

TABLE 41 Pupils' answers to the question of whether they trust more in their teacher than television when environmental problems are concerned

	Frequency	%
always	34	3.9
often	120	13.8
sometimes	424	48.6
seldom	213	24.4
never	81	9.3
Total valid	872	100
Missing	11	
Total	883	

There is no significant difference in the answers of Finnish and German pupils with regard to the above question (chi-squared = 7.0, p = 0.13). When girls and boys were studied separately, it was found that there is a difference in attitudes (chi-squared = 29.8, p = 0.00), but it is not clear which of the sexes trust more in their teacher. Of the boys 20.4% believe in their teacher often or always, but the corresponding percentage for girls is only 14.7%. On the other hand, a comparably large part of boys (38.3%) believe in their teacher seldom or never, and for the girls the number is much smaller (28.7%).

The Finnish pupils also trust in newspapers and the Internet more than German pupils (table 42). The items were: "What is written in a newspaper is usually true" and "I get trustworthy information from the Internet".

TABLE 42 Trust in newspapers and the Internet by country of pupils

		absolutely agree	almost agree	partly agree	almost disagree	absolutely disagree	total
Finland	Newspaper	8.9 %	30.1 %	41.9 %	14.6 %	4.6 %	632
Germany	Newspaper	3.3 %	18.3 %	52.3 %	16.2 %	10.0 %	241
	Count	64	234	391	131	53	873
Finland	Internet	9.8 %	21.7 %	44.1 %	18.6 %	5.8 %	295
Germany	Internet	4.3 %	12.8 %	19.1 %	12.8 %	51.1 %	47
	Count	31	70	139	61	41	342

The biggest difference is in the attitude towards the Internet. More than half of the German pupils disagree absolutely with the claim "I get trustworthy information from the Internet", compared to less than 6% in Finland. For both cross-tabulations the differences of countries are very significant ($p < 0.001$, chi-squared test).

7.3 The correlation of behaviour and opinions with general environmental attitudes and attitudes towards chemistry and the chemical industry

The Spearman correlation coefficients between the sum variables SVA, SVC and SVB were calculated. (table 43). There is a very significant correlation between all pairs of variables. Especially the correlation between the behaviour variable SVB and attitude variable SVA is strong, taking into account the large sample sizes and the correlation coefficient close to 0.5.

TABLE 43 Correlation of the variables general environmental attitude (SVA), behaviour and activity (SVB) and attitude towards chemistry (SVC). The 1996 and 2000 studies (first numbers refer to the 1996 study)

		Behaviour and activity (SVB)	Attitude towards chemistry(SVC)
General environmental attitude (SVA)	r	0,45-0,48	0,23-0,18
	p	0,000-0,000	0,000-0,001
	N	523-327	526-325
Behaviour and activity (SVB)	r		0,20-0,16
	p		0,000-0,004
	N		526-323

Scales A and B measure "positive" and "negative" environmental attitudes and behaviour. To see how pupils from different class grades, sexes and countries differ on the attitude/behaviour scale, the means of the variables SVA and SVB were calculated for each group Then these means were subtracted from the total SVA and SVB means to obtain an ordered pair (attitude difference from mean, behaviour difference from mean) for each group. When these ordered pairs are placed in the attitude/behaviour coordinate system, the relative placement of each group can be seen (figure 14).

Figure 14 well describes the attitudes and behaviour of the different pupil groups. Girls in general and German pupils have the most positive environmental attitudes and Finnish boys the least positive. The Finnish girls report the most environmentally favourable behaviour. All groups in the 2000 study are located on the negative side of the behaviour axis. The answers of German girls in 2000 deviate most from the above mentioned attitude/behaviour correlation. It might be partly because of the small sample of German pupils in 2000.

It must be noted that the mean of all pupils is placed on the origin (0,0). The placements of different groups are relative to this mean and the negative coordinates do not necessarily refer to negative attitudes or negative behaviour.

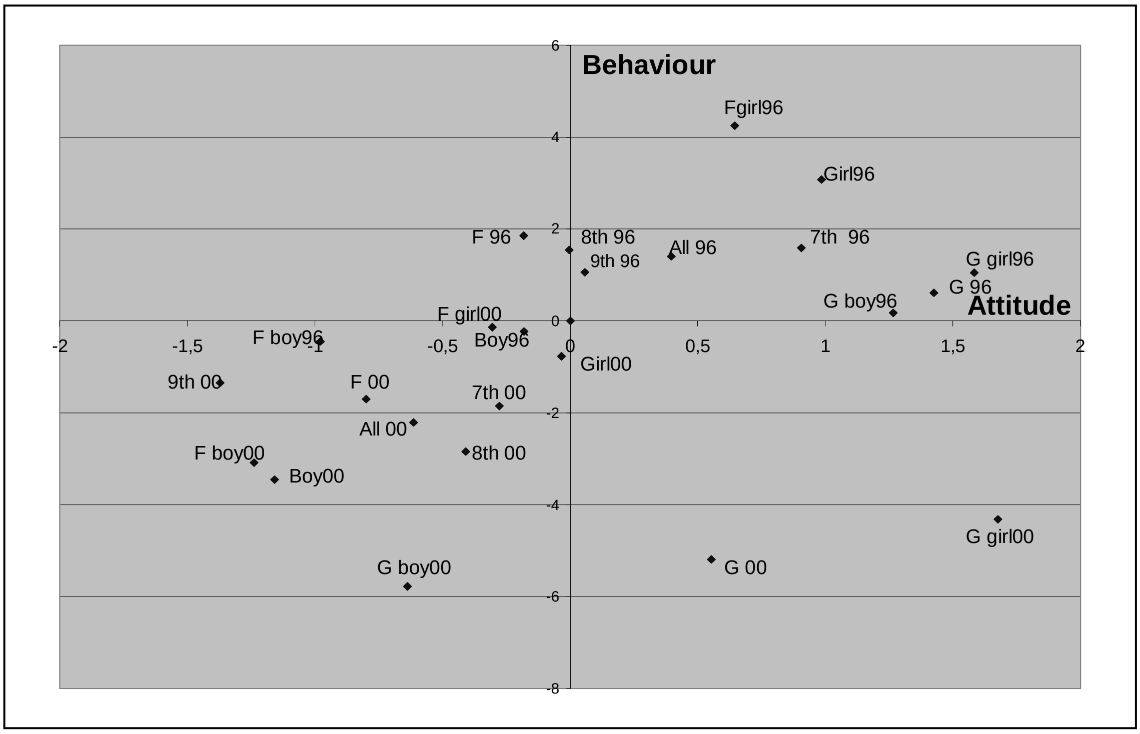


FIGURE 14 The relative placement of the different pupil groups on the attitude/behaviour coordinates (N = 839).

In the 1996 study the girls are much higher on the attitude and behaviour axis compared to the total mean (origin), but in 2000 the girls' coordinates are only slightly on the positive side on the attitude scale and on the negative side on the behaviour scale. The change on the behaviour scale has been even faster with the girls than with the boys, but the attitudes of the boys have become more negative than the girls' attitudes.

7.4 Pupils' attitudes and behaviour compared to the information sources

It is of interest to find out if there are differences in the pupils' attitudes with respect to their information sources. The number of environmental concepts studied was eight. Thus, for each information source there is a number from zero to eight describing the variety of environmental information a pupil has obtained from the source. These variables have been described earlier (chapter 7.1).

The non-parametric correlation between the above mentioned variables and the sum variables SVA, SVB and SVC was calculated. Table 44 includes the main results. The non-significant correlations have been left out except in the case of other than science teacher as information source. Usually the correlation between the information source variable and the attitude variables is negative, i.e. the more information a pupil gets of any source, the more positive is his environmental attitude.

TABLE 44 Significant correlations (in bold print) between the use of the information sources and the formed variables SVA, SVB and SVC

	Attitude		Behaviour and opinions		Attitude towards chemistry		
	rho	**p**	**rho**	**p**	**rho**	**p**	**N**
TV and Radio	-0,06	0,07	-0,15	0,00	-0,12	0,00	813
Newspapers or magazines	**-0,10**	**0,01**	**-0,24**	**0,00**	**-0,12**	**0,00**	813
Science teacher	0,01	0,70	-0,14	0,00	-0,07	0,05	813
Other teacher	**0,09**	**0,01**	0,08	0,03	0,01	0,875	813
Parents	**-0,15**	**0,00**	**-0,29**	**0,00**	-0,05	0,16	813
Greenpeace or WWF	**-0,15**	**0,00**	**-0,21**	**0,00**	-0,05	0,17	813
Conservation organisation	**-0,13**	**0,00**	**-0,24**	**0,00**	-0,07	0,05	813
Internet	-0,05	-0,05	**-0,18**	**0,00**	0,01	0,92	284

It seems that pupils who acquire their information from many information sources, such as parents, environmental organisations and newspapers have more positive attitudes and behaviour on the constructed scales than the average pupils. The positive attitude towards chemistry is gained when television and radio and newspapers are used as information sources. The only information source that seems to affect the pupils negatively on the attitude and behaviour scales is the teacher, especially other than a science teacher (rho > 0).

The correlation is significant for the coefficients whose absolute values are rather close to zero because of the high value of N. Nevertheless, most of the coefficients of determination (rho-squared) are small and it is unclear whether the use of an information source has a very clear effect on pupils' attitudes or behaviour. By comparing the correlation coefficients, it is possible to deduce that at least environmental information from homes, newspapers, TV and radio and environmental organisations has a positive influence on environmental attitudes and behaviour.

7.5 Results of the laboratory observation

7.5.1 Pupils behaviour during laboratory session

Either student teachers or the researcher videotaped all laboratory sessions using a single video camera. The tapes were analysed afterwards by the researcher in order to get more information concerning what happened in the classroom while pupils were carrying out the laboratory experiments. Since only one video camera was in use, only a very small area of the classroom could be observed at a time. Therefore it did not provide much evidence of pupils' behaviour or conversations during the laboratory sessions. To interpret the possible information that the videos would give was too complicated. More than one video at the same time would have provided much more evidence for the study.

The number of laboratory sessions that pupils took part in varied from one to four. For each pupil a number was given to describe his behaviour in the laboratory. This number was one (responsible) if the observer had marked B2=0 and B3=0. In case one of the codes B2 or B3 was one, the behaviour number was zero (non-responsible). Most of the pupils attended more than one laboratory session. To obtain a single index to describe a pupil's environmental behaviour, the mean of the above described behaviour numbers was calculated for each pupil (table 45).

TABLE 45 The number of laboratory sessions pupils attended and the calculated environmental behaviour on the scale 0-1

	Number of experiments the pupil attended				
Environmental behaviour	1 exp	2 exp	3 exp	4 exp	total
0,00	16	8			24
0,25				1	1
0,33			7		7
0,50		32		3	35
0,67			28		28
0,75				3	3
1,00	53	5	4		62
total	69	45	39	7	160

The numbers describing the pupils' environmental behaviour were compared to the sum variables that were calculated according to the questionnaires the pupils had completed. The correlation coefficients and their significance for the correlation of attitude variable A, behaviour and opinion variable B and attitude towards chemistry variable C with the behaviour observed in the laboratory are presented in table 46.

TABLE 46 The correlation of environmental behaviour in the laboratory with the sum variables SVA, SVB and SVC

	Spearman's rho	p
Attitude A	-0.08	0.30
Behaviour B	-0.08	0.32
Attitude/chemistry C	-0.05	0.51
N	158	

The correlations are negative, as could be expected, because on the scales of variables SVA, SVB and SVC a small value denotes a positive attitude or behaviour as opposed to the number describing environmental behaviour in the laboratory. The correlation is not, however, significant and hence it cannot be claimed that a positive environmental attitude or positive general environmental behaviour leads to environmentally responsible behaviour in the laboratory.

The results indicate (see table 45) that the environmental behaviour of the pupils varied from one laboratory session to another. Of those 91 pupils who took part in two or more laboratory activities, only 17 (19%) behaved similarly every time.

7.5.2 The effect of teaching on pupils' behaviour

To find out if behaviour in the laboratory was dependent on instruction, the correlation of behaviour index with instruction methods was calculated for each laboratory activity. Most of the correlations are not significant. The p-values of the correlation are listed in table 47.

TABLE 47 The significance of the non-parametric correlation of laboratory behaviour index with the different types of instruction (The pupils had no special instruction for the fifth activity, making a superball.)

	Electrolysis	Battery test	Reactivity	Beating heart
Expert teaching	----	0.17	0.02	0.55
Instruction before	0.24	0.04	0.01	0.74
Instruction during	0.24	0.47	0.95	0.59

It appears that no type of special instruction has an overall effect on environmental behaviour in the laboratory. The instruction given before the laboratory sessions had a positive effect ($p < 0.05$) with two activities, namely the battery test and reactivity of metals, and expert teaching improved the behaviour in the case of reactivity of metals ($p < 0.05$). Table 47 reinforces that the behaviour in the laboratory changes according to the activity. The teacher's instructions sometimes have a positive effect, but when pupils handle different kinds of waste, the instruction may no longer have the same power and effect.

The results of the correlation tests were checked using cross-tabulation of classified attitude and behaviour variables A, B and C with classified laboratory behaviour. The laboratory behaviour was divided into two categories *responsible* (a pupil had behaved in an environmentally responsible way during most of the laboratory activities) and *non-responsible* (a pupil had behaved in a responsible way at most during every second laboratory activity). The cross-tabulation and chi-squared test did not yield any new information compared to table 46. The questionnaire answers of “responsible” and “non-responsible” pupils did not differ significantly.

It was also studied whether the appearance of the recycling basket helped the pupils to make the right decisions about the waste. It turned out that the

(Spearman) correlation of responsible behaviour with the appearance of the recycling basket was non-existent for the battery test, but almost significant for the testing of the reactivity of metals. The p-values were 0.91 and 0.04, respectively. The same results, even with almost equal significances, were obtained with chi-squared analysis (table 48). A special basket for recycling was available only in a few cases during the three other laboratory activities, so its effect could not be tested. Again it can be seen that pupils behave differently during different laboratory sessions.

TABLE 48 Cross-tabulation and chi-squared analysis of the effect of a recycling basket on pupils' environmental behaviour during two laboratory sessions

			Non-responsible	Responsible	Total	chi-sq. test
Testing batteries	Recycling basket available	N (no)	21	9	30	chi-sq. = 0.016 p = 0.90
		%	70.0 %	30.0 %	100 %	
		N (yes)	25	10	35	
		%	71.4 %	28.6 %	100 %	
		Total	46	19	65	
		%	70.8 %	29.2 %	100 %	
Reactivity of metals		N (no)	20	53	73	chi-sq. = 4.36 p = 0.04
		%	27.4 %	72.6 %	100 %	
		N (yes)	10	64	74	
		%	13.5 %	86.5 %	100 %	
		Total	30	117	147	
		%	20.4 %	79.6 %	100 %	

The study also examined whether behaviour in the laboratory correlates with the total amount of pupil's sources of environmental information or with the number of information sources about recycling. In both cases the answer is negative: the significance of the correlation tests are $p = 0.28$ and $p = 0.17$, respectively.

The differences in laboratory behaviour may be due to different practices in schools. In two schools the pupils attended the same activities so their behaviour can be compared. The comparison was made using Mann-Whitney's non-parametric test for comparing means (table 49). Only during one laboratory activity did behaviour differ almost significantly ($p<0.05$).

TABLE 49 The Mann-Whitney test for comparing differences in laboratory behaviour of pupils from two schools. (N1 and N2 refer to the number of pupils attending from the two schools)

		Responsible behaviour, *battery test*		Responsible behaviour, *reactivity*		Responsible behaviour, *beating heart*		Responsible behaviour in laboratory, *mean*	
Mann-Whitney U		490		1778		176		2485.5	
Wilcoxon W		815		3731		254		4831.5	
Z		-0.17		-2.25		-0.55		-0.27	
p		0.86		0.02		0.59		0.79	
N1	N2	40	25	62	68	12	32	75	68

It was mentioned before that the age of the pupils does not very much affect environmental attitudes. When the laboratory behaviour of the pupils was compared, using age (13-15) as a grouping variable, no significant differences were found. (table 50). Four 12-year-old pupils and one 16-year-old pupil were omitted from the Kruskall-Wallis test. Only two laboratory activities, where the number of different aged pupils was large enough were taken into account, as well as the mean of laboratory behaviour.

TABLE 50 Comparison of the differences in laboratory behaviour of different aged (from 13 to 15 years) pupils

	Responsible behaviour, *battery test*			Responsible behaviour, *reactivity of metals*			Responsible behaviour in laboratory, *mean*		
Chi-Square		0.29			0.34			4.81	
df		2			2			2	
p		0.86			0.84			0.09	
N_{13} N_{14} N_{15}	12	39	10	39	73	34	48	73	34
	Kruskal Wallis Test								

As in earlier analyses, significant differences can be found when studying the effect of gender on environmental behaviour. The behaviour of the girls in the laboratory is more responsible when measured by the criteria described earlier. The difference is significant in average behaviour and in one activity, and almost significant in one activity (table 51).

TABLE 51 Gender differences in laboratory behaviour

		Responsible behaviour, *electrolysis*		Responsible behaviour, *battery test*		Responsible behaviour, *reactivity*		Responsible behaviour, *beating heart*		Responsible behaviour, *mean*	
Mann-Whitney U			125		479.5		2141.5		159.5		2374
Wilcoxon W			296		885.5		4032.5		435.5		4789
Z			-1.17		-0.65		-2.71		-2.50		-2.75
p			0.24		0.52		0.01		0.01		0.01
N_{girl}	N_{boy}	18	16	37	28	86	61	21	23	91	69
Grouping Variable: Gender											

The results show that both the environmental attitudes and behaviour of girls are more positive than those of boys. The differences in laboratory behaviour vary from one activity to another.

8 GENERAL DISCUSSION AND CONCLUSIONS

The focus of this study was *first* the investigation of young pupils' - in four Finnish schools and one German school in Frankfurt - views on eight environmental issues: *catalytic converter, ozone hole, acid rain, car exhaust, greenhouse effect, water pollution, harmful substances,* and *recycling* and the main information sources from which pupils got information about these issues. *Secondly,* it looked at pupils' environmental attitudes and their self-reported environmental behaviour. *Thirdly,* it focused on their real environmental behaviour in the active experimental working situation in the science laboratory.

In particular, the study looked at student age and gender differences in the level of acquiring information from various sources, their environmental attitudes generally and towards chemistry and chemical industry as well as their own opinions concerning opportunities to influence the environment through their own behaviour. In all these cases the present study also revealed differences between some Finnish and German pupils and focused on possible changes between 1996 and 2000. Among these the study looked at the differences between Finnish pupils' behaviour in four schools situated in different parts of Finland as well as the dependence of behaviour on the teachers' instructions given when working with different activities in the laboratory.

This chapter will discuss what the results tell us about the main questions raised in this thesis: pupils' main information sources on environmental issues, environmental attitudes and their environmental behaviour in the school laboratory. Two written questionnaires, an evaluation study during the laboratory experiments, and the effect of the way teachers' give instructions on pupils' behaviour were studied.

In the first section of this chapter (8.1.), the following questions are addressed:

- What are the main sources of knowledge of Finnish and German pupils on environmental issues?

- Do Finnish and German pupils differ in acquiring information on certain environmental issues from certain sources and are there any meaningful differences between genders and age groups?
- Are there meaningful differences in pupils’ attitudes and behaviour based on questions asked of pupils?
- Are there significant differences on pupils’ attitudes and behaviour in practice?
- In all these cases are there any differences between age groups, genders or countries?
- Have there been any notable changes in these from 1996 to 2000?

This chapter will also discuss what these findings tell us about the teaching of environmental issues, giving instructions in the chemistry laboratory, and developing pupils’ environmental attitude towards certain issues. It will discuss especially what the findings tell us about environmental information and knowledge and their effect on environmental attitude. The methodological implications (section 8.2) are also discussed and further research is outlined (section 8.3).

8.1 Main results and conclusions

8.1.1 Information sources on environmental issues

As expected, television and radio turned out to be the main sources of environmental issues for 12- to 15- year-old pupils. According to this study most pupils get their main environmental information from television and radio. In regard to gaining information from television and radio there is a difference of only four units in favour of Finnish pupils compared to German pupils. This result is highly supported by the earlier study of Wiesenmayer, Murrin and Tomera (1984), who, according to Solomon (1992), indicated that television is the most used information source. In his earlier study including four countries, Australia, England, Israel and United States, Blum (1987) had also got a similar result that the most important information sources on environmental issues for pupils were the mass media: radio, television, and the press. There had actually been a change in this since 1971 because according Bailey's study (1971), newspapers had been the most important source of environmental knowledge and television had been the fourth most important after interpersonal and other information sources. Twenty years later Solomon's study (1992) proved that science teachers had the most important role as the source of pupils' science issues in Britain in the beginning of 1990s. Based on her study, even as much as 95 % of the science knowledge of 17-year-old pupils came from science teachers, 61 % from reading, 31 % from television, and 12% from talking with friends. Also the survey of Detjen (1995) proved that 68% of the public in US got most of their environmental information from television, 59 % from newspapers and only

19% from school. These findings are supported by many other researchers mentioned in Rickinson's (2001) review study, among them Morris and Schagen (1996, 14), who studied 15-16 year old pupils in the United Kingdom and found television to be the most important source of information about the environment. As also mentioned by Rickinson, the study of Chan (1998) showed that only 'TV news watching' correlated strongly with pupils' environmental knowledge.

Based on this study the next most important information sources after television and radio were science teachers, newspapers/magazines, and parents. The role of the science teacher is significantly higher in Finland than in Germany whereas movies and Greenpeace or the WWF seem to play a significantly greater role as environmental information sources in Germany than in Finland. Parents are a significant information resource in both countries immediately after science teachers and newspapers. This study shows also that Finnish pupils get more knowledge from newspapers than German pupils. An interesting finding was that friends as information sources are exactly equally important in both countries. Also Blum (1987) had ended up with similar results that parents and friends were important information sources in England, Australia and Israel. The role of teachers other than science as an information source seems to be a bit larger in Finland than in Germany. This may partly depend on interpretation of the term "other teacher", since there is a possibility that some pupils classify a biology teacher as "other teacher" and the others as "science teacher." These results are in line with the study of Chan (1996), which proved school to be the second most important source of pupils' environmental knowledge right after television.

When looking at the gender differences and information sources of all the pupils involved, the results showed that in both countries boys get significantly more information from television and movies than girls. An interesting question had been to ask how many hours boys and girls watch television per day, since to some extent this might be the reason for these differences. Girls on the contrary seemed to gain more information from their science teacher and parents. Some interesting questions can be raised from these results: Do the ways movies and television present environmental issues reach boys easier than girls? Why do girls gain significantly more information from science teachers than boys? Could this knowledge be used in teaching? When the gender differences between Finland and Germany were compared, it turned out that the differences were greater in Germany than in Finland. In Finland only the importance of television and radio as an information source was significantly different for boys and girls. Finnish boys got much more information from television than girls.

When comparing class grades and the amount of environmental information, one would have expected that the older the pupils, the more information they gain from different sources and the more marks they would have in their questionnaire. However, the results showed that older pupils had got significantly more information only from their science teacher and from TV and radio. Younger pupils emphasized the role of parents. In the 2000 results, when the Internet was included as an information source, it turned out that the older pupils get significantly more information from the Internet than the younger ones. This study confirmed that the familiarity of environmental issues increases with the age. There is a small possibility that this result, in the case of Finnish pupils, is due to curricula differences, since schools in Finland are very independent in this sense. However, in the German case this is not an explanation since the study icluded only one German school.

Like some earlier findings (Blum 1987; Detjen 1995), this study also confirmed that the school was less common as a source of environmental information than television and radio. Therefore it is quite obvious that schools and teachers have much to do to improve the knowledge base of pupils. This finding is strongly supported by the study of Kuhlemeier, Van den Bergh and Lagerweij (1999), who found strong differences between schools when environmental knowledge was tested and interpreted their results to be mainly caused by differences between types of training.

8.1.2 Familiarity of environmental concepts

Recycling seemed to be the most familiar environmental concept from the eight concepts studied when all pupils were looked at. Next came *exhaust gases, water pollution,* and *ozone hole*. This study clearly proved that all eight concepts were very well known among pupils, since over 90% of pupils also knew *acid rain,* which was the least known concept of all the concepts studied. For German pupils the ozone hole was the most often mentioned concept whereas in Finland it was recycling. The results are in line with the earlier study of Prelle and Solomon (1996), who stated that the ozone hole was the environmental issue that German and English pupils considered the most important. Also according to them German pupils thought the rain forest and threat to wildlife to be the next most important while English pupils informed that it was acid rain and the threat to wildlife. This study showed that German pupils saw recycling, water pollution and exhaust gases to be the next most important while Finnish pupils considered them to be water pollution, exhaust gases and the ozone hole.

In general, the level of environmental knowledge and scientific knowledge in Finland and Germany is quite high. In a comparative study Finns placed fifth and Germans ninth among people from 21 industrialised countries. (Tanskanen 1997).

As noted by Prelle and Solomon (1996), some differences between nations and genders maybe explained through familiarity and appreciation of different environmental issues. Some issues such as, for example, river pollution are certainly not as important for pupils who do not live near rivers. As Baley (1971) wrote already in the early 70s, education plays an important role as a predictor of environmental knowledge and subsequent behaviour. Unfortunately, in many cases studied the level of pupils' factual knowledge of environmental issues seems to be quite low. A study of Kuhlemeier, Van den Bergh and Laferweij (1999, 7) reports that a large part of the pupils responded by "I really do not know" when they were asked if statements on certain environmental topics were correct or not. This means that they were uncertain about the right answer. However, in the light of Kuhlemeier's and others results it also seems very interesting that when Tung, Huang and Kawata (2002) studied the effect of special educational programs in four different schools on pupils' environmental knowledge, environmental attitudes and environmental concern, they found no significant increase in these.

According to the study of Waterworth and Waterworth (2000), the factors that control human actions can be presented as three levels: knowledge-based behaviour, rule-based behaviour and skill-based behaviour. Knowledge-based behaviour is conscious, rule-based behaviour partly conscious, and skill-based behaviour is unconscious. Pupils usually use knowledge-based behaviour. When working in the laboratory they should, however, also use rule-based behaviour. If they use this behaviour, it should be based on environmental rules for working in the laboratory discussed earlier with the teacher.

Based on the results of Prelle and Solomon (1996), German students had generally more correct information about all the issues they studied than English pupils. Those issues were litter, acid rain, ozone hole, threat to wildlife, rain forest, cars and transport, nuclear power, farming methods and rivers. They estimated that German pupils had learned more about these issues at school than had English ones. As was noted in the previous chapter, this estimation of Prelle and Solomon seems quite reliable in the light of the present study, which shows that the most important information sources of German pupils were mass media and science teachers.

With regard to age differences, this study clearly stated that pupils get information about recycling from numerous sources already in the 7th grade. As a matter of fact, recycling is the only concept for which the number of information sources does not increase significantly with the age of the pupils.

Some gender differences could also be found in respect with various environmental concepts. Girls mentioned recycling significantly more often than boys. When the catalytic converter or acid rain were looked at the boys mentioned them significantly more often than girls. In the case of the catalytic converter it is understandable because most boys are more interested in cars than girls are, but in the case of acid rain this difference is harder to understand. Is this such a concept that girls do not pay so much attention to? The study of Prelle and Solomon (1996) showed the same type of difference in the case of the concept acid rain.

8.1.3 Environmental attitudes

According to the pupils' subjective self-reported results their *general environmental attitudes* turned out to be quite positive. Unlike the study of Lyons and Breakwell (1994), this study showed that girls' attitudes on environmental issues were more positive than boys’. This result is also supported by several Finnish studies (Järvinen 1995; Helve 2001). Also the attitudes of German pupils were more positive than Finnish pupils, but this difference was no longer significant in 2000. This may be due to the small amount of German pupils in the

2000 study. We need to remember when talking about attitudes that they can also affect on the individual's relationships with others, determining the acceptable patterns of social interaction.

Age was not found to significantly affect environmental attitudes. This was a good result because Tognacci and others claimed (1972) that age and gender were poor predictors of concern. Even though some researchers (Van Liere & Dunlap 1980) later found that age is inversely related to positive environmental attitudes when comparing older and younger people, this finding was not comparable in the present study since in my study the age difference between pupils compared was so small. Inconsistent findings were reported by Lyons and Breakwell (1994), who studied pupils' attitudes towards industrial pollution and found that age was positively related to environmental concern. They studied pupils whose ages ranged from 13-16 years and concluded that the differences might reflect differences in school curricula. Also according to the study of Leeming and Dwyer (1995), age had some, but not significant, effect on environmental attitudes. Similar results were obtained by Boyes and Stanisstreet (1993), who studied the greenhouse effect and children's perceptions of causes, consequences and cure.

There was an almost significant difference between schools in attitudes. The difference was due to two schools in Central Finland. The country school was clearly more negative and the suburban school more positive compared to the median attitudes in other schools. It is impossible to say, based on this study, what has most affected this result, the teachers, parents or friends.

The findings of this study showed that there was no positive correlation between pupils attending an *environmental chemistry course* and positive attitudes. This result was inconsistent with the study of Bradley, Waliczek and Zajicek (1999), who wrote that increased knowledge might help improve environmental attitude. The present study indicates the opposite and it seems that pupils' attitudes have generally changed in a negative direction, even though one might reasonably think that pupils' understanding of science issues is higher today than it was in 1996. It is very difficult to understand this negative direction. Maybe one reason is that science teachers as well as television and radio have disseminated environmental news in a more negative way because so many pollution problems have arisen during these years.

In general, boys' attitudes towards *chemistry and the chemical industry* were more positive than girls. This study showed that the difference had increased during five years. In Finland the difference between boys and girls had become significant in the years studied with girls' attitudes growing more negative and boys' attitudes moving in a slightly more positive direction, when looking at chemistry or chemical industry. In Germany boys' attitudes seem to be significantly more positive than those of girls in both studies and the difference has increased mainly due to the fact that girls' attitudes have become more negative, just as in Finland. These results strongly underline that there are notable differences between genders, contrary to what some previous studies (Lyons & Breakwell 1994; Ebenezer & Zoller 1993) have informed.

It is worthwhile noticing that the general negative attitude toward *studying chemistry* has grown in both countries. The similar study of Ebenezer and Zoller (1993) showed practically no change in the percentages of pupils who expressed a positive attitude toward school science from 1986 to 1989. Their study was done in British Columbia secondary schools at the grade 10 level. It would be interesting to know what the result today would be or what the result in Finland and Germany would have been in the late eighties.

It is interesting that German pupils, whose attitudes towards environmental issues in general were more positive than Finnish pupils, express quite strongly that they do not like to study chemistry. This was also the case among German boys whose attitudes towards chemistry and the chemical industry were found to be highly positive. Blum (1987) reported that he found indicators that boys and girls differ in the interest they took in various topics at school (e.g. boys more in energy generation, girls more in health). These results together with my study lead to the conclusion that something must be wrong in the way chemistry is taught at schools in Finland and in Germany or in the way information sources present their information on chemistry and the chemical industry. Especially it is very worrying that the attitude of Finnish girls has noticeably changed in a more negative direction. In the 1996 study almost half of them informed that they like to study chemistry, compared to only one fifth in 2000. However, the present study also proved that the Frankfurt pupils involved dislike studying chemistry more than Finnish pupils and confirmed the gender-based differences in attitudes towards chemistry.

As alarming as the result of this study is that pupils' attitudes towards studying chemistry as well as chemistry and the chemical industry have become more and more negative, equally obvious is the fact that action to improve this should start immediately since, as we know, the change in pupils' environmental attitudes and concern is very slow. It seems obvious that the media tend to focus on environmental failures or disasters, in keeping with its general bad news orientation. This leaves room for scientists to present positive sides of scientific research and to popularise it.

Since it has been proved in the literature that attitudes will also develop through learning, an effort should be put into teaching so that these attitudes would not develop purely by chance. Especially teachers should pay attention to the attitudes towards objects arising in the study of science subjects, such as industry, applications and development.

8.1.4 Personal opinion and environmental behaviour

The environmental opinions of girls are more favourable to the environment than boys. No significant difference was found between class grades or between Finnish and German pupils. Whether pupils had had the environmental course or not did not have much effect on pupils' opinions and behaviour. My study clearly states that pupils' opinions on environmental questions have changed into a more negative direction. However, Finnish girls believe more than boys in their own possibilities to influence their environmental welfare and so do German girls. It is worth noticing that both Finnish and German boys also seem to have partly lost interest in trying to fight for a cleaner and safer environment and so they also answered as if a clean environment would not have as much meaning for them as earlier. Some separate questions showed that certain issues, such as "to buy plastic bags or not", were more important for German pupils than for Finnish pupils. It is understandable since in Germany they have had a lot longer experience of separating waste than in Finland and plastic is the waste that causes many problems. On the other hand, the German pupils' answers seem to indicate that they appreciate a clean nature less than earlier and they think that their behaviour does not have very much effect on getting a cleaner environment.

The connection between environmental education and environmental behaviour is not at all simple, as Prelle and Solomon (1996) wrote. They stated that even though many people in Germany and Britain may be environmentally active and have a good knowledge of environmental issues, this does not at all mean that they would be ready to do anything in practice in favour of their own environment. This study is supported by the study of Heinonen and Kuisma (1995), which proved that Finnish young people have very positive attitudes to many environmental issues such as restriction of traffic, avoiding use of plastic bags, supporting recycling, etc. Also according to their study young people believe that environmental favourable behaviour is going to increase in the near future. However, their study also proved that young people do not - as independent persons - take the responsibility for polluting the environment but are more likely to think that industry or states are responsible. Similar results were also obtained by Ajzen and Fishbein (1980b), who found out that even though people are concerned, for example, about climate change, they tend to use their cars since their attitude (toward climate change) is not closely related to their behaviour (driving).

An interesting as well as worrying finding was also that German pupils - more than Finnish pupils - have lost their concern for what really happens to waste and that this seemed to be the growing trend. Also discussion of environmental problems seemed to diminish among German as well as Finnish pupils. In both countries girls still seem to be slightly more interested in solving environmental problems than boys. These result findings appear to be similar to the results of Kuhn (1979) and Van Liere and Dunlap (1981), whose study proved that women are more concerned about the environment than men. Also the findings of Scott and Willits (1994) suggested that there might be gender differences in expressing support towards some environmental issues.

When the correlation between behaviour and environmental attitudes was, studied a significant correlation was revealed although some previous studies have given different results (Newhouse 1990; Scott & Willits 1994). Girls in general and German pupils as a group have the most positive attitudes in the1996 study. Finnish boys at the same time have the most negative environmental attitudes as well as self-reported behaviour. When the class grades were examined, the study shows that the younger the pupils, the more positive their attitudes are. These results make one wonder whether it is so that the more we talk about environmental problems, the more negative attitudes we create? A very interesting finding was revealed when looking at the two studies, in 1996 and in 2000, separately: a very notable change in a negative direction could be seen both in attitudes and behaviour. In the 1996 study girls' attitudes and behaviour seemed very positive, but it had fallen sharply by 2000. We need to initiate serious discussions on why this has happened. Also girls' behaviour had moved in a negative direction faster than that of boys', but the attitudes of boys, on the contrary, had turned more strongly in a negative direction than those of girls.

This study revealed that German pupils, at least those living in Frankfurt seem to have changed their environmental behaviour very strongly in a negative direction from what it used to be in 1996. However, the small amount of German pupils in the 2000 study leaves this result open to question and suggests that further study is needed to be able to confirm this result. Based on this study, it is impossible to know exactly which has had a stronger effect on pupils' self-reported behaviour, whether, for example changes in curriculum, growth of negative information in television, radio and newspapers, changes in science teaching or some other unknown factor.

8.1.5 Believing in information

Based on pupils' own self-reported information, this study revealed that most pupils have slightly more trust in the information they get from television than that from their science teacher as far as about environmental problems are concerned.

Fortner and Lyon (1985) were also convinced of the importance of television as an information source for pupils. Some years later Ostman and Parker (1989) found in their study that television is not useful as an environmental information source, in contrast to newspapers.

My study proved that no significant difference was found between Finnish and German pupils when comparing how much trust they have in their teachers as information sources and in television. However when looking boys and girls separately, there seemed to be a difference in the amount of trust, but because of the format of the questionnaire it is not clear if the boys trust more in their teacher than girls or vice versa. Finnish pupils seemed to have clearly more trust in newspapers and the Internet as knowledge sources for environmental information than German pupils.

The most remarkable difference between countries was in the degree in confidence in the information obtained from the Internet. Over half of German pupils in Frankfurt questioned the reliability of the information from the Internet and only a few Finnish pupils had the same opinion. Why is this difference so big? A possible explanation for this could be that German pupils involved in the present study had made less use of the Internet than Finnish pupils, especially at school. Maybe German teachers are not as willing to use the Internet in their teaching as Finnish teachers. When pupils use it on their own, they do not know where to find the reliable information. For years teachers at schools in Finland have given addresses of reliable www-pages for pupils to find the information wanted about certain issues and it is quite usual to give pupils project tasks where they need to find a lot of information from the Internet to be able to fulfil the task demands.

8.1.6 Pupils' attitudes and behaviour compared to the information sources

Important research findings were produced when the differences in pupils' attitudes with respect to their information sources were looked at. This study showed that usually the more information pupils receive from any source, the more positive their environmental attitudes seem to be. This is consistent with some previous studies (Bradley & Waliczek 1999), whose findings suggested that increased knowledge may help improve environmental attitude. Similar results were also recorded by many other researchers according to De Young (1996), who proposed that relevant knowledge on a certain environmental issue is the most significant predictor of observed behaviour.

When parents, newspapers or environmental organisations were information sources on environmental issues, pupils' attitudes and behaviour were above the average on the positive scale. Television and radio as well as newspapers seem to help to create positive attitudes towards chemistry. The only information source that seems to affect pupils' attitudes negatively is ´other than science teacher´. This result is in contradiction with the study of Wong and Frazer (1996), who stated that teachers should teach environmental issues also in non-laboratory classes.

Furthermore, since this study has proved, as some previous studies (for example, Blum 1987), that the role of a science teacher was the most important source of pupils' environmental knowledge right after mass media, educators have much to do in teaching pupils to develop a positive attitude to science as well as to become critical learners when using different information sources. Especially today, pupils need to apply critical thinking in evaluating the information they gain from the Internet since the Internet has a growing role as a pupil's source of knowledge. This study showed that 10 % of Finnish pupils and 7.6% of those German pupils taking part in this research gained their information on environmental issues through the Internet. Because the German sample only consisted of pupils from one school, this difference is within the error margins. At the same time as the role of the Internet has grown, the role of television and radio as well as of newspapers and parents has noticeably diminished. This study also reveals that the older the pupils are, the more meaning the Internet has for them. A very interesting finding is that the Internet has not affected the role of science teachers, which has actually grown a little during the period of research.

Since most of the coefficients of determination are small, this study cannot prove with absolute certainty that the use of an information source has a meaningful effect on pupils' behaviour. It can only be deduced that at least environmental knowledge that pupils get from home, newspapers and environmental organisations has a positive influence on pupils' environmental attitudes and behaviour.

8.1.7 Results of the laboratory observation

This research gave no evidence that a positive environmental attitude or positive general environmental behaviour as a subjective self-reported estimation leads to environmentally responsible behaviour in the chemistry laboratory. Based on this study, pupils' environmental behaviour varied from one laboratory session to another. There was no proof of the assumption that the same pupil would behave similarly (meaning either in an environmentally responsible or irresponsible way) in each laboratory session when the experimental part differs.

The fact of whether a pupil had attended an *environmental chemistry course* before the laboratory session or not had no significant meaning for behaviour. According to the results, it seems clear that no type of special instruction has very much effect on pupils' environmental behaviour in the laboratory. Only teacher instructions given just at the beginning of laboratory sessions had a statistically significant positive effect on two activities, namely 'testing batteries' and 'reactivity of metals'. Expert teaching caused environmentally responsible behaviour only in the case of 'reactivity of metals'. Since pupils’ behaviour seemed to change depending on the activity, it is impossible to make any generalisations on this. Teacher instructions given just before the activity sometimes had a positive effect, but also this changed when pupils had to handle different kinds of waste. How much pupils' prior experience affected their behaviour in the laboratory was not studied (Halloran 1967; Lee& De Young 1995). According to the study of Lee and De Young, prior experience was shown to be an excellent predictor of behaviour in certain situations. These results on the effect of teaching on pupils’ behaviour are supported by the theories of Fishbein and Ajzen (1975) as well as Ajzen and Fishbein (1980b). They pointed out, for example, that even people who are very aware and concerned about climate change tend to drive a car. The same phenomena are clearly seen in the results of this study.

One question asked was whether those pupils who, according to their answers to the questionnaire, seemed to be environmentally responsible had also behaved in a more responsible way than the other pupils in the chemistry laboratory. This study indicated that this was not the case. No significant differences were found in their behaviour in the real situation.

One explanation for varying and quite random behaviour in the laboratory context can be explained by using the theory of Bagozzi (1992, 194). According to him "*a present-oriented intention* is a personal decision to act immediately." In this study it could happen that a pupil had some used batteries in his hand and he asked from his classmate what he should do with them or he just threw them in a waste basket. Unless an unlikely event of sufficient magnitude arises straightaway, the present-oriented intention will lead to action. This kind of unlikely event could, in the case of this study, have been, for example, the chemistry teacher who told the pupil what he should do with the used batteries. Also as Bagozzi (1992, 195) wrote *"a future-oriented intention* is a decision to act later." He explains two cases that are of interest and can be applied directly to this study. If, for example, in the first case one pupil decides at a time t_1 to act at a time t_2 and if the time difference between t_1 and t_2 grows, it may happen that the pupil will change his intention. Alternatively, some unexpected event, such as teachers' instructions or talking with friends, can make the pupils' intention impracticable or undesirable.

Pupils' behaviour in the laboratory by no means seemed to correlate with the number of information sources pupils had reported. Also in the case of certain environmental issues, for example "recycling", no correlation was found. According to the research findings presented above it can be deduced that neither the large number of information sources in general that pupils receive their information from nor the variety of information sources they get information on a certain environmental issue, for example "recycling", guarantees any effect on their behaviour in the real situation.

The earlier study of Hines and others (1986) reported a correlation of 0.299 between knowledge and environmentally responsible behaviour. According to my study, it seems that the greater number of information sources pupils get knowledge from does not necessarily guarantee increased knowledge, or the amount of knowledge is no guarantee of the development of positive environmental attitudes or behaviour. Based on the theories of Dewey (1933) and Kolb (1984), Ojanen (1995, 60-73) says that people are not aware of the connection between their theory in practise and their attitudes and behaviour. Peoples' behaviour depends on their attitudes and unconscious assumptions, which have more effect on their behaviour than the knowledge that feeds them.

The differences in laboratory behaviour might also be due to different school practices in general. When two schools were compared, the behaviour of pupils differed almost significantly only during one laboratory activity, namely "reactivity of metals". There was no significant difference between the age groups either, even though the study of Brody, Chipman and Marion (1988-89), for example, concerning the concept of acidic deposition stated that the level of understanding of this issue grows in accordance with class grades.

However, girls were found to behave in a more environmentally responsible way than boys. The difference between genders was significant when looking at average behaviour and almost significant in the case of one laboratory activity. Girls' environmental attitudes as well as behaviour are more positive than boys.

In conclusion my study showed that there is no special group of pupils that displays positive environmental attitudes and responsible behaviour on all occasions. However, this might be partly due to the laboratory experiments since they differed quite much from each other and it is not so easy to interpret which behaviour was environmentally responsible and which was not. Also it turned out that the best activity was "reactivity of metals". This might be because it is obvious to those pupils who have at all listened to their teacher that strong acids cannot be thrown in the sink. It should be noted that the classification scale describing the behaviour of pupils used in this study was far from unambiguous.

8.2 Methodological reflections

8.2.1 Research strategy and selection of research subjects

Three different research methods were originally used in the study: 1) questionnaires, 2) laboratory experiments together with the observation procedure including notebooks completed during the session and diary notes as well as video technology, and 3) interview of teachers. The teachers' interview did not give as much information as was originally wanted to because the amount of teachers (8 teachers) was so small that the information obtained from the interviews was not very reliable. As mentioned earlier, the information obtained from videos was too difficult to interpret since only one video camera at a time was used and only a part of the behaviour of pupils could be observed based on videos. Also it was revealed in the course of the study that people making notes during the laboratory sessions should have been trained more carefully since they produced only very short notes and less systematically than had been planned.

The reason for using cluster sampling technique when choosing schools, teachers, classes and pupils in the study was mainly to have a sample of convenience. Because only one school from Germany could be included in this study, it was not possible to obtain random samples yielding research data that could be generalised to a larger population within margins of error that can be determined statistically (Borg & Gall 1989, 220)

The following requirements refer to the reliability of measurement and to the validity of measurement, respectively (Levine 1994): In a recent review of 34 studies that attempted to measure the effectiveness of environmental education, Leeming, Dwyer, Porter, and Cobern (1993) found 33 studies that incorporated an environmental attitude or knowledge scale design. All but one of these studies employed a project-developed questionnaire to measure attitudes and/or knowledge, that is, a scale that was created specifically for the particular study. Obviously, no single scale is widely used to measure children's attitudes toward and knowledge of a broad range of environmental issues. Leeming and others, among many other researches, have pointed out that it is essentially impossible to make meaningful comparisons across these various studies because the comparability of the instruments is unknown. Typically, the authors of the reviewed studies provided very little information about the reliability of their respective instruments and virtually nothing was reported about validity, other than an assertion that the items were developed and selected by knowledgeable "experts." Although expert opinion is important in scale construction, researchers should according to Leeming and others (1993) also use other forms of scale validation.

The questionnaire used was designed for the purpose of this study by taking account of a type of questionnaire that other researchers had used earlier (Hofstein, Ben-Zvi & Samuel 1976). Many people have later used a similar type of scale to the one used in this research. (Hernández, Suáres, Martínez-Torvisco & Hess 2000). When measuring attitudes, Hofstein and others used a 5-point Likert-type scale: 5, "fully agree"; 4, "agree"; 3, "undecided", 2, "partially agree"; and 1, "fully disagree". After reading several research papers (Schuman & Presser 1981; Leeming & Dwyer 1995; Hofsten, Ben-Zvi & Samuel 1976), I decided to use the 5-point Likert-type response format (i.e. very true, mostly true, not sure, mostly false, or very false) attitude scale similar to Leeming and Dwyer (1995). However, now that I have carried out the research, I think it would have been better to use bipolar evaluatory statements instead (Bentler & Speckart 1979; Smith & Biddle 1999; Ajzen & Madden 1986). It would have given more reliable information than this traditionally used scale. In that case I could have used more items for the scales without making the questionnaire too long.

I used four categories when analysing questionnaire A testing attitudes. The number of items varied in different categories. However, for future research, I would consider equalising the number of items in each category as far as possible. Also, similar items may be replaced in favour of more diverse ones, although on occasion similar items could be advantageous to confirm consistent responses. A similar type of attitude and knowledge scale was also used in the study of Leeming and Dwyer (1995). The questions used by them forced pupils to provide better information on their knowledge base because they used the format presented in the following example. Example: Question 4. Phosphates are harmful in sea water because they a) cause cancer in fish, b) stop reproduction in fish, c) make fish nervous, d) make the water cloudy, e) suffocate fish by increasing algae. This type of questionnaire would have been another possibility for use in this research, but the choice had already been made two years earlier before I saw this study using the questionnaire described earlier (appendix 2).

8.2.2 Data analysis and the validity of the measurements

The implicit assumption that a questionnaire is a true measure of a particular attitude must be subjected to question, according to many researchers. Even if a pupil tries to reply honestly, there is no guarantee that the reply will be valid when he is placed in any particular situation relating to his expressed attitudes. Many people have also tried to measure behaviour by using questionnaires and have inferred the attitude from this by assuming that personality and social environment affects are randomised or irrelevant. There may be a basis for this if the samples being studied are large and random. Attitudes are rarely self-consistent and compartmentalisation of attitudes and behaviour is frequent. For example, knowledge of the danger of smoking and anti-smoking feeling does not guarantee that a person will have a negative attitude to smoking and that he will not smoke. However, Henerson, Morris and Fitz-Gibbon (1987) wrote that if the researcher has a variety of concerns, most of which could be covered by asking straightforward questions, one can consider the use of a questionnaire. Provided that common sense is used in test construction, appropriately large samples are involved, and the measurements are replicated, reliability problems will be reduced to reasonable proportions. The qualitative (interview) part together with questionnaire would have improved the picture of pupils' attitudes towards science.

By definition a measure is totally reliable when individuals are perfectly consistent in their response to a questionnaire (Levine 1994). One weakness of this study was the use of self-reports on behaviour. In this type of self-reported behaviour pupils may express higher consistency than an observation of overt behaviour might reveal. Also, according to the book edited by Summers (1971, 140), "the reliability of the scale can be ascertained by preparing two parallel forms from the same material and by presenting both forms to the same individuals." The correlation between the two scores obtained for each person will indicate the reliability of the scale. In this study the pre-test was carried out and for a small part of pupils the same questions used in the pre-test were also presented in the final test. There was no significant difference found in pupils' answers in these two cases.

The scales constructed for my study appeared to be reliable, based on the study of Cronbach alpha. As expressed by Gooch (1995), Cronbach's alpha coefficient is a common method used to measure a scale's internal reliability. The scales are also discriminative based on correlation studies between the sum variables and the items of the scales and the close-to-normal distributions of the variables. Validity of the measurements and the conclusions drawn on the basis of them cannot be fully verified using computational methods. (Nummenmaa, Konttinen, Kuusinen & Leskinen 1997.) The validity of the scales was improved by studying the items of the questionnaire and discarding those that did not seem to measure the chosen phenomena. The correlation comparisons of items within and outside the scales gave evidence for the validity of the conclusions based on the questionnaire.

The scale used in studying pupils’ environmental behaviour in the chemistry laboratory was categorised in seven categories. This scale and interpretation of the data on pupils' behaviour in the laboratory leaves much room for argument, something which I found only after running my research. I cannot be sure if the classification into environmentally responsible and non-responsible behaviour used in this study was a reliable one. This leaves room for a subsequent study with a more reliable scale.

8.2.3 Generalisation of the findings

This study clearly reveals that knowledge and environmental concern are gained mainly not in school but from numerable other sources, television and radio being one of the favourites. Both Finnish and German boys involved in this research gained significantly more environmental information from television than girls. Other than that, there were not very many differences between genders in gaining knowledge from certain information sources. This may be partly due to the fact that all German pupils were living in huge city of Frankfurt and maybe the result would have differed if there had also been pupils from the German countryside. The second most important information source in both countries was the science teacher together with newspapers and parents. This means that the science teacher has a very important position in taking care of the knowledge base of pupils. As stated by Wood in 1974, environmental education should convey at least three aspects of environmental awareness: 1) exposure to knowledge concerning the man-environment relationship, 2) development of skills and abilities and 3) development of attitudes of responsibility and appreciation toward environment (Wood 1974).

Since environmental attitudes will also develop during the process of learning and since attitude development includes learning experiences and materials as well as attitudes towards the teacher, this makes the role of the science teacher even more important in developing pupils' environmental knowledge base and attitudes. As stated by Kwan and Miles (1998, 12), teachers should be able to identify and draw on pupils' opinions about the environment in order to achieve success in environmental education. As mentioned earlier, according to the recent study of Tung and others (2002), the effect of special educational programs on environmental knowledge, environmental attitudes as well as environmental concern seems to very minor

When talking about attitudes we must remember that they can provide a framework to make sense of the world around in terms of knowledge, feelings and behaviour. Attitudes can also provide internal sense for the individual, bringing beliefs, feelings and behaviour into a logical and rational wholeness of meaning. Attitudes can as well make sense of an individual's relationships with others, determining the acceptable patterns of social interaction. Knowing that, it is a major question to think about how much of these results as well as the previous results of other studies can be explained by *role playing behaviour*. This is very characteristic, especially of young pupils, as they learn to make sense of knowledge as well as of themselves and their social world. When pupils sit next to each other, they may think that they need to answer in a certain way - no matter how they think or feel - when it is question of the environment.

My research proposes that attitude development is not simply dependent on the acquisition of relevant information. Since pupils receiving precisely equivalent teaching from the same teacher give totally different kinds of answers, it must be that the different prior knowledge and attitude that pupils have may well bias the individual as they respond and process the new information. The new information has to be comprehended and assessed in a certain way, this often depending on the information and attitudes already present. This may also partly explain the differences in the age groups and genders that have been found in this study.

It is obvious, according to this and many other studies, that environmental attitudes will develop even if there is no attempt to consider them in a planned way in setting up educational programmes. Therefore teachers should be aware of this and provide their pupils with opportunities to develop environmental attitudes in a structured and coherent way. They should also help their pupils to find the meaningfulness of the whole learning process. In addition, knowing that attitudes will develop toward the *subject matter being studied*, chemistry (and science) teachers have a great challenge to make sure they present environmental issues in a positive way: chemistry is not causing all the environmental problems but is also solving a lot of problems and helping people in many different ways.

As seen in this study, environmental opinions of girls in both countries were more favourable to the environment than those of boys, and even if the pupils in Finland had had the environmental chemistry course, it did not have a positive effect on boys' attitude in general. This finding is supported by the studies of Mikkola (2001,127) and Helve (2001). Their studies proved that Finnish men and boys are more likely to put economic welfare ahead of environmental aspects than women and girls. Most worrying is that my study clearly points out that pupils' opinions on environmental questions have become more negative since 1996. The boys in both countries also seem to have lost their interest in saving their environment and their answers reflect a lack of concern. Is it so that pupils of today are more realistic than they used to be five years ago? Or is it that their content knowledge has grown compared with earlier and with increased knowledge idealistic opinions disappear. An interesting finding is that, according to both samplings, German pupils dislike chemistry much more than Finnish pupils. This must have something to do with the media as well as with science teachers since these are the biggest information sources for pupils.

8.3 Implications for the future research

In this study the number of items varied in the four categories - general attitude, attitudes towards chemistry /the chemical industry, personal opinion/ environmental behaviour, and believing in information - that were used to find out pupils' attitudes towards environmental issues as well as the chemical industry and chemistry. However, for future research, I would consider equalising the number of items in each category as far as possible.

When the gender differences and information sources of all pupils involved were examined, the results showed that in both countries boys get significantly more information from television and movies than girls. It would be worthwhile studying how many hours of television boys and girls watch per day, since to some extent this might be the reason for these differences. Because television seems to be so important as an information and knowledge source for pupils, researchers should make more careful use of interactive television techniques in studying the meaning of television as an information and knowledge source on environmental issues for pupils. Is it so that the way movies and television present environmental issues reaches boys more easily than girls? It would be interesting to study why girls gain significantly more information from science teachers than boys. Would it be possible to use this knowledge in teaching chemistry?

The importance of the science teacher for pupils’ behaviour in the science laboratory should be studied in a more systematic way than in this study. As Sanders and others (1993) have shown in their study, the influence of science teachers’ content knowledge, pedagogical knowledge, and pedagogical content knowledge on teaching is evident. Therefore, the teachers should be trained first by educators to be totally aware of environmental issues and given help in finding ways to teach in an environmentally concerned way. They should be trained to be environmentally conscious and responsible, as Kiiskinen (2001, 165-166) declared in her thesis. The classes of these trained teachers and other comparable classes should then be used to run the same laboratory experiments without any advice for pupils on handling waste and then to study the differences in behaviour. In this way it would be possible to make a more reliable comparison of how big the effect of the teacher on pupils’ environmental behaviour really is. The scale should also be carefully constructed.

Since in this study only eight environmental issues were studied, namely: *catalytic converter*, *ozone hole*, *acid rain*, *exhaust gases*, *greenhouse effect*, *water pollution*, *harmful substances*, and *recycling*, an examination of the consistency among a wider range of environmental issues would be useful. For example, wilderness, traffic, energy pollution, overcrowding, public health, energy sources, population density, etc. could be included in the next study (see, for example, Tognacci et al. 1972, Blum 1987). It would also be interesting to ask pupils in different countries simply what they consider to be the main environmental problems today, globally and nationally, and what their attitudes are on them. This kind of study might give teachers some advice as to where they should pay more attention when teaching.

Blum (1987) studied pupils' knowledge and beliefs concerning environmental issues in four countries, namely the US, Australia, England and Israel and found that ranking environmental issues differs from country to country. In addition according to Gooch's study (1995), for example, the most serious environmental concern of the inhabitants of Riga and Tartu were water pollution from towns and factories, something that was not considered very serious problem in Sweden in 1995. The next most serious concerns mentioned in this study were water pollution from farmlands and industrial waste. These studies among several others prove that there are many similarities as well as differences between countries that ought to be studied in order to find some global answers. It would be interesting to know whether the answers concerning the environmental issues of today would differ if Western and Eastern countries as well as, for example, African countries were compared? And what about pupils' self-reported behaviour concerning these issues - would it be the same? Since, according to Van Liere and Dunlap (1981), solving environmental problems depends more on pro-environmental behaviour than pro-environmental attitudes, studying these is really important.

It would also be very interesting to study more deeply why the interest of girls towards studying chemistry has dropped during the research period so remarkably. One would even expect that since the role of the science teacher has grown, the attitudes of pupils would become more positive.

The effect of special educational programs on pupils’ environmental knowledge, environmental attitudes as well as their environmental concerns also deserves more study. It would be interesting to know if the results would support those of Tung and others (2002) if the study programs were longer and carried out in different countries.

YHTEENVETO

Johdanto ja tutkimuksen tarkoitus

Taustaa. Yleismaailmalliset ympäristömuutokset yhdessä jatkuvasti kasvavan informaatiotulvan kanssa asettavat valtavia haasteita ympäristöopetukselle. Nykyinen tietoyhteiskunta on informaatioteknologian kehittymisen myötä tuonut mukanaan monenlaisia haasteita sekä opettajille että vanhemmille, mutta myös tiedotusvälineiden edustajille. Haasteet kohdistuvat erityisesti luonnontieteiden opettajiin ja erilaisiin tietolähteisiin, jotka tuottavat ympäristöasioihin liittyvää informaatiota. Se, kuinka paljon tietoa koululaiset saavat erilaisista ympäristöasioista, riippuu tutkimuksen mukaan opettajien - erityisesti luonnontieteiden opettajien- ja tiedostusvälineiden edustajien asiantuntijuudesta. Myös vanhemmilla on aina ollut ratkaiseva asema koululaisten ympäristötiedon lähteenä. Aikaisemman tutkimuksen mukaan koululaisten ympäristötietouden lähteinä edellä mainittujen lisäksi toimivat myös erilaiset luonnonsuojelujärjestöt, Greenpeace, WWF, kuluttajajärjestöt sekä kuntien ja kaupunkien virkamiehet. Koska opettajilla ja tiedotusvälineillä on ratkaiseva merkitys koululaisten ja muiden kansalaisten ympäristöä koskevan tiedon kehittymisessä ja ympäristövastuullisten ja -tietoisten kansalaisten kasvattamisessa, pitäisi heidän olla näiden asioiden asiantuntijoita. Ympäristötietouden kehittymiseen liittyy myös ympäristöasenteiden kehittyminen joka edelleen vaikuttaa ihmisten käyttäytymiseen ja päätöksentekoon.

Tavoite ja tarkoitus. Tämän tutkimuksen tarkoituksena oli selvittää, mistä koululaiset saavat tietoa ympäristöasioista ja mihin tietolähteisiin he eniten uskovat sekä miten tieto vaikuttaa heidän asenteisiinsa ja käyttäytymiseensä kemian laboratoriotunneilla. Tutkimuksella selvitettiin joidenkin tietolähteiden tärkeys ja merkittävyys koululaisten ympäristötiedon lähteinä. Käytetyt tietolähteet olivat televisio ja radio, luonnontieteiden opettaja, sanomalehdet, vanhemmat, muut kuin luonnontieteiden opettajat, elokuvat, ystävät, luonnonsuojelujärjestöt, Greenpeace tai WWF, erilaiset kuluttajajärjestöt, kuntien ja kaupunkien virkamiehet ja Internet. Ympäristötietoisuuden ja vastuullisuuden selvittämiseksi tutkittiin myös eri ikäisten oppilaiden ympäristöasenteita ja ympäristövastuullista käyttäytymistä sekä kyselylomakkeen avulla oppilaiden omaan subjektiiviseen arviointiin perustuen että kemian laboratorioluokassa työskentelyä seuraamalla. Tutkimuksella selvitettiin myös koululaisten käyttämien informaatiolähteiden ja heidän ympäristöasenteidensa ja käyttäytymisensä välistä mahdollista yhteyttä sekä ajan mukanaan tuomia mahdollisia muutoksia oppilaiden ympäristökäsitteiden tuntemisessa, asenteissa ja ympäristökäyttäytymisessä.

Johtuen Euroopan Unionin maiden pyrkimyksestä opetuksen yhtenäistämiseen, jota Bolognan sopimus kuvastaa, ja opettajankoulutuslaitoksemme Sokrates vaihto-ohjelmasta Frankfurtissa sijaitsevan J. W. Goethe -yliopiston välillä tutkimukseen otettiin mukaan yksi suuri koulu Frankfurtista, Saksasta. Koulun valinta oli puhtaasti käytännön syistä johtuva, sillä ohjaajani tunsi tästä koulusta opettajan, joka oli halukas suorittamaan kyselyni koulussaan.
Tutkimuksessa käytetyt ympäristökäsitteet olivat *katalysaattori, otsoniaukko, happosade, autojen päästöt, kasvihuoneilmiö, veden saastuminen, haitalliset aineet ja kierrätys.*

Tutkimusongelmiksi täsmentyivät seuraavat kysymykset:
Mitkä ovat 12-15 -vuotiaiden oppilaiden pääasiallisimmat informaatiolähteet, mistä he saavat tietoa ympäristöasioista ja kuinka tuttuja nämä kyseiset asiat ovat oppilaille?
Millaiset ovat oppilaiden asenteet ympäristöasioita kohtaan heidän omien arvioidensa mukaan?
Löytyykö oppilaiden ympäristöasenteiden ja -käyttäytymisen välillä riippuvuutta?
Onko informaatiolähteiden ja oppilaiden ympäristöä koskevien mielipiteiden, asenteiden tai käyttäytymisen välillä riippuvuutta?
Mikä vaikuttaa oppilaiden ympäristökäyttäytymiseen laboratoriossa?

Metodit

Empiirisessä tutkimuksessa selvitettiin opettajia haastattelemalla, olivatko he opettaneet ympäristökemian erikoiskurssin oppilaille ennen tutkimuksen toteuttamista ja samalla tutkittiin heidän omaa asennoitumistaan ympäristöasioihin. Haastatteluun osallistui kahdeksan opettajaa neljästä eri koulusta Jyväskylästä ja sen ympäristöstä sekä yhdestä Pohjois-Suomen koulusta. Haastattelulla selvitettiin myös sitä, millä tavalla ja missä vaiheessa opettajat antoivat oppilaille ohjeita laboratoriotyöskentelyyn ja eri vaiheessa annettujen ohjeiden vaikutusta oppilaiden ympäristökäyttäytymiseen oppilaslaboratoriossa.

Aktiivista laboratoriojaksoa, joka koostui erilaisista kemian töistä, käytettiin tutkittaessa oppilaiden käyttäytymistä oppilaslaboratoriossa. Tutkimukseen osallistui yhteensä 160 oppilasta samoista kouluista joista haastateltavat opettajat olivat. Mukana oli viisi seitsemättä luokkaa, neljä kahdeksatta luokkaa ja yksi yhdeksäs luokka. Oppilaat osallistuivat kukin yhdestä neljään laboratoriojaksoon. Kokonaisosanotto laboratoriokokeissa oli 304 (vrt. taulukkoon 45).

Tutkimusta varten valittiin viisi erilaista kemian työtä, joista yhdessä käytettiin ympäristön kannalta erityisen haitallisia yhdisteitä: kaliumdikromaattia ja elohopeaa. Oppilaiden käyttäytymistä laboratoriojakson aikana tutkittiin havainnoimalla, käyttämällä opettajan ja opetusharjoittelijoiden jakson aikana tekemiä muistiinpanoja sekä tutkijan päiväkirjamuistiinpanoja ja opetusharjoittelijoiden kuvaamia videonauhoja.

Tutkimuksessa käytettiin sekä kvalitatiivisia että kvantitatiivisia menetelmiä täydentämään toisiaan. Kvalitatiivinen osio koostui oppilaiden ympäristökäyttäytymisen luokittelusta sekä opettajien haastattelusta. Opettajien haastattelulla tutkittiin, missä vaiheessa opettajat antavat ohjeita ympäristöystävällisestä laboratoriokäyttäytymisestä, esimerkiksi laboratoriotöissä käytettävien haitallisten aineiden laittamisesta keräilyastioihin tai heittämisestä viemäriin. Opettajahaastattelulla selvitettiin myös opettajien omien ympäristöasenteiden mahdollista vaikutusta oppilaiden ympäristökäyttäytymiseen. Kvantitatiivisia, oppilaiden omaan raportointiin perustuvia kyselylomakkeita käytettiin tutkittaessa oppilaiden ympäristöasioihin liittyvää tietoa ja tiedonlähteitä sekä heidän ympäristöasenteitaan ja -käyttäytymistään. Oppilaiden ympäristötietoutta ja mielipiteitä ympäristöasioista sekä asenteita ympäristöasioita kohtaan tutkittiin kahden erilaisen kyselylomakkeen avulla. Ensimmäinen kyselylomake koostui 34 väittämästä, joiden avulla selvitettiin oppilaiden mielipiteitä asenteista ympäristöasiota kohtaan sekä käsitystä omasta ympäristökäyttäytymisestään. Toisen kyselylomakkeen avulla tutkittiin, mistä tietolähteistä oppilaat saavat tietoa ympäristöasioista. Tutkimukseen valittiin kahdeksan yleistä ympäristökäsitettä.

Pohdinta ja johtopäätökset

Tämä tutkimus osoittaa selvästi, että tiedotusvälineet (media) ovat luonnontieteiden opettajien ohella yläasteikäisten oppilaiden tärkeimmät ympäristöasioita koskevan tiedon lähteet. Tämä tieto asettaa haasteita kemian ja yleisemmin luonnontieteiden opettajille. Jos kemian ja luonnontieteiden opetuksen yhtenä päämääränä on tuottaa ympäristölukutaitoisia ihmisiä on yhtenä opetuksen ja oppimisen avainkysymyksenä nähtävä ympäristömyönteisten asenteiden ja ympäristöopetuksen pedagogiikan kehittäminen. On selvää, että ympäristöasenteet kehittyvät myös koulujen opetusohjelmista riippumatta. Tietoisina tästä opettajien tulisi tarjota oppilailleen mahdollisuuksia positiivisten ympäristöasenteiden kehittämiseen johdonmukaisella ja järjestelmällisellä tavalla. Opettajien tulisi auttaa oppilaitaan näkemään oppimisprosessin merkityksellisyys ympäristöasioista puhuttaessa.

Tutkimuksellinen ja kokemuksellinen ympäristöasioiden käsittely tuottaa vastuullista ympäristökäyttäytymistä (Ramsey & Hungerford 1989). Tämän vuoksi on erittäin tärkeää, että opettajat pyrkivät niin paljon kuin mahdollista yhdistämään teorian ja käytännön opettaessaan ympäristöasioita. Hofstetterin (2000) mukaan 8-12 vuotiaat lapset, jotka katsovat televisiota ja lukevat sanomalehtiä, tietävät enemmän ajankohtaisista asioista kuin muut luokkatoverinsa. Koska televisiolla, radiolla ja sanomalehdillä näyttää olevan keskeinen osa oppilaiden tietolähteinä, opettajien olisi myös entistä enemmän kiinnitettävä huomiota oppilaiden lukutaidon ja erityisesti medialukutaidon kohottamiseen.

Joitakin ympäristöasioihin liittyviä eri kansakuntien ja sukupuolten välisiä eroja voidaan Prellen ja Solomonin (1996) tutkimuksen mukaan selittää tiettyjen ympäristöasioiden tuttuudella tai niiden tärkeydellä oman elämän kannalta. Jotkut asiat, esimerkiksi jokien saastuminen, ovat tärkeämpiä sellaisille oppilaille, jotka asuvat joen varrella kuin muualla asuville. Bailey (1970) kirjoitti jo 70-luvulla, että koulutuksella on tärkeä asema ympäristötiedon ja ympäristökäyttäytymisen ennustajana. Waterworthin ja Waterworthin (2000) tutkimuksen mukaan ihmisen toimintaa kontrolloivat tietoon perustuva käyttäytyminen, sääntöihin perustuva käyttäytyminen ja taitoihin perustuva käyttäytyminen. Tietoon perustuva käyttäytyminen on tietoista, sääntöihin perustuva osittain tietoista ja taitoihin perustuva tiedostamatonta. Oppilaiden käyttäytyminen on useimmiten tietoihin perustuvaa. Työskennellessään koululaboratoriossa heidän pitäisi kuitenkin käyttäytyä myös sääntöihin perustuvan käyttäytymismallin mukaisesti. Sääntöihin perustuvan käyttäytymismallin pitäisi koululuokassa perustua ympäristötietoiseen laboratoriokäyttäytymismalliin, josta on keskusteltu opettajan kanssa ennen laboratoriojaksoa.

Tarkasteltaessa koululaisten yleisiä ympäristöasenteita tutkimus osoitti, että koulujen välillä oli tilastollisesti melkein merkitsevä ero. Ero johtui kahden Keski-Suomessa sijaitsevan koulun vaikutuksesta. Mielenkiintoinen tulos oli, että kyseisessä tapauksessa maaseutukoulun oppilaiden asenteet ympäristöasioita kohtaan olivat tutkimuksen mukaan selvästi kielteisemmät kuin kaupunkikoulun oppilaiden. Tutkimus ei selitä mistä ero johtuu, mutta yksi merkittävä tekijä saattaa olla opettajan rooli. Toinen selittävä tekijä voisi olla lasten omien arkielämässä saatujen kokemusten väliset erot: kaupunkilaisilla on etäisempi, monesti ihannoiva näkemys. Näiden tekijöiden tutkimuksellinen selvittäminen tarjoaa mielenkiintoisen haasteen seuraavalle tutkimukselle.

Tämä tutkimus osoitti, että oppilaiden asenteet kemian opiskelua ja kemian teollisuutta kohtaan ovat muuttuneet yhä kielteisemmiksi vuosien 1996 ja 2000 välillä. Tämä on erittäin huolestuttavaa ja on ilmeistä että välittömästi pitäisi ryhtyä toimiin tämän asian korjaamiseksi. Näyttää siltä että tiedotusvälineet kiinnittävät paljon enemmän huomiota ympäristöongelmiin ja -katastrofeihin ja niiden yhdistämiseen kemiaan kuin kemian myönteisiin saavutuksiin. Tiedemiesten ja kemian sekä muidenkin luonnontieteiden opettajien olisi pyrittävä tuomaan esiin ympäristöasioissa tapahtuneita positiivisia muutoksia ja kemian osuutta niihin erityisesti popularisoidessaan tiedettä.

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APPENDICES

(1-5; an English translation of the originals)

APPENDIX 1

Questionnaire A

Grade .... First name..

The name of your school...

Circle the right alternative:

I am a) a girl b) a boy

I have had the environmental chemistry course: a) Yes b) No

Dear Student

On the following pages you can see sentences. I would like you to read them carefully and answer them carefully and to be as honest as possible. Please do not think what you would suppose your teacher would like you to answer but just what you think is your personal opinion. The answers will be only used for my research work and no one else will know your personal opinion. Please write down your first name just in case I would like to do another questionnaire later.

You will be a great help to me if you work carefully through the questionnaires. Please answer quickly after first reading - while you think - and try to answer each question. Be aware that you cannot do anything wrong, because this is not an exam testing your knowledge but this is my interest concerning your environmental opinions ("poll") and knowledge.

NB. Do not go backwards when answering the questions. Just keep going all the time and write down your honest answers.

Example:
I like to play football always often sometimes seldom never
Circle one of the words that you think is your opinion. If you always like to play football, just circle the word **always.** If you like to play football only sometimes, circle the word **sometimes**, and so on.
Do you understand everything?

THANK YOU FOR YOUR CO-OPERATION !

General attitude (attitudes) on environmental problems

1	By recycling we can save resources and leave resources untouched	always	often	sometimes	seldom	never
2	I think acid rain is no problem in Finland/ in Germany	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
3	Old medicines should be returned to the drugstore	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
4	When our family buys washing detergent, the main criteria is that it courses as little harm to the environment as possible	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
5	Greenhouse effect will raise the temperature in our country in the future	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
6	Used chemicals should not be thrown in the sink	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
7	It is sensible to separate papers from other waste	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
8	All talk about the greenhouse effect is exaggerated	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
9	It makes sense to separate different waste and not just put it all in the same place	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
10	We should not send our waste to the undeveloped countries	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion

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Attitudes towards chemistry (attitudes) /chemical industry

11	I think that chemistry is necessary when solving environmental problems	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
12	I think the chemical industry causes more troubles than benefits	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
13	The chemical industry has an important role in solving environmental problems	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
14	A knowledge of chemistry can help when we try to minimise environmental pollution	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
15	We should not spent as much money on chemical research as we do at the moment	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
16	We would be in trouble without chemistry and its applications	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
17	I think chemistry is an absolutely unnecessary science	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
18	We can often avoid using the products of the chemical industry	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
19	I think that chemical products are important	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
20	I like studying chemistry	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion

My personal opinion/ environmental behaviour

21	Before throwing something away, I think over whether it can be used for some other purpose	always	often	sometimes	seldom	never
22	If I am active enough, I can do a lot to save nature	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
23	I am interested in knowing as much as possible about environmental problems and how to solve them	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
24	I use rechargeable batteries	always	often	sometimes	seldom	never
25	I think it is good that we learn more about air and water pollution at school	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
26	It is actually all the same to me what happens to the waste, the most important is to get rid of it	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
27	To be honest, I am not interested in the problem of expanding amount of waste and air pollution	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
28	My behaviour has very little to do with getting a cleaner environment	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
29	A clean environment is very important for me	I have exactly the same opinion	I have almost the same opinion	to some extent the same opinion	I have quite different opinion	I have totally different opinion
30	When I go shopping, I buy a plastic bag to take..	always	often	sometimes	seldom	never
31	I discuss envir. problems with my schoolmates	always	often	sometimes	seldom	never
32	We talk about environmental problems at home	always	often	sometimes	seldom	never

Believing in information

33	When we discuss environmental problems I believe more in my teacher than the information I get from television	always	often	sometimes	seldom	never
34	What is written in newspaper is mostly true	absolutely agree	almost agree	partly agree	almost disagree	totally disagree
35	I get reliable information from the Internet	absolutely agree	almost agree	partly agree	almost disagree	totally disagree

APPENDIX 2.

Questionnaire B

First I want to know ***where you get different types of information from***. In table 1 you will find some concepts and if you know what they mean you should answer where you have got your information from. For example, if there is the concept "acid rain" and you think you know something about it, you should mark X in the columns, from where you have got the information, for example: TV, newspaper, your science teacher, some other teacher and so on. Mark as many X's as you think are necessary. If the concept is unknown to you , mark X in NOWHERE column and if you think I have missed some source of information, name them using the empty lines.

Information source	Catalytic converter	ozone hole	acid rain	exhaust gas	greenhouse effect	water pollution	harmful substances	recycling
TV and radio								
Internet								
Newspaper or some other paper								
Movies								
Friends								
Teacher of physics, chemistry or biology								
Some other teacher								
Parents								
Greenpeace or WWF								
Some other nature conservation organisation								
Consumer organisation								
Information from city, or rural commune								
I do not know where I got the information from								
I do not know the concept(word)								

APPENDIX 3

LABORATORY EXPERIMENTS USED IN THIS RESERACH

Laboratory experiments (E1- E5):
Electrolysis (E1)
Testing batteries (E2)
Reactivity of metals (E3)
Beating heart (E4)
Synthesis of a superball (E5)

Experiment E1: ELECTROLYSIS

The following experiment modified by Asunta (1993) from the one originally presented by Bader and Kloss (1992) was used.

Background/ subject information
There is a lot of discussion about if it would be possible to use hydrogen as an energy-source in the future. The following experiment tries to deal with the problems that present this idea of being realised and teach the students the principle of making hydrogen from the water.

A water molecule has three atoms: two hydrogen (H) atoms and one oxygen (O) atom. It can be electrically broken up in these parts. The electric current cannot go through distilled water but when you add for example some sodium carbonate to the distilled water, the electric current can go through it.

Reactions: anode: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ (oxidation)
cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (reduction)

In the electrolysis reaction you will get twice as much hydrogen as oxygen.

Students' preconceptions
The purpose is first to find out how much students know about the water molecule. Students are forced to think about the subject by using different questions in some way or other related to the water molecule, such as:

Formally hydrogen was used in the balloons (used for celebration) - why it is not allowed any more?
How is it possible that fish can breathe in water?
Do you know anything about electrolysis? and so on.

Problem
Can you make hydrogen from tap water?

The aim of this laboratory activity

The aim was to study what students will do when they find out that there are some batteries that no longer work.

We will follow students working and give them advice when it is asked for, but not earlier. We will reserve a wastebasket for batteries in the classroom and another basket (just an ordinary one). We will mark down what students do: if he/she will ask the teacher where to put the used battery, just throw it into the waste basket or leave it among the others and take another battery.

Equipment and materials

* 3 batteries (4,5 V)
* 2 plastic syringes (5 ml)
* pieces of metal wire(e.g. Cu) or two safety pins
* one decanter or drinking glass
* tablespoon
* sodium carbonate
* piece of wood
* hooks
* matches
* water

Duration of experiment
45 minutes

Procedure
As explained in the experiment by Bader and Kloss (1992). See figures 3, 4, and 5.

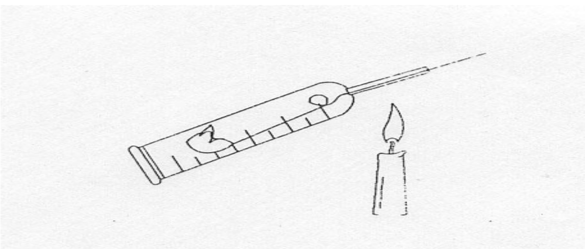


Fig 3 Make the electrode carefully, so that there will be no holes

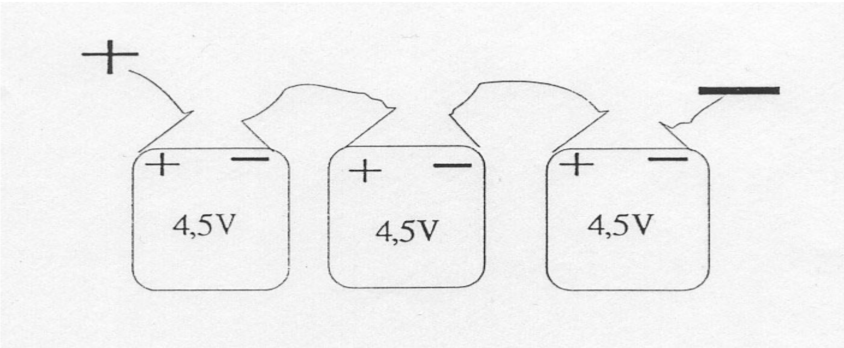


Fig 4 Connect the batteries in series

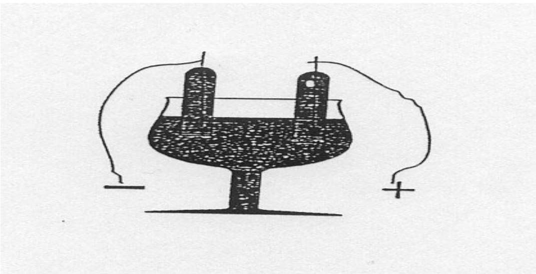


Fig 5 Connect the electrodes to the batteries

Let the electrolysis happen and test what you got.

Observe

Do not let the gases escape. One of them is lighter than air - which one?

Results and discussion

In how many cases did the students make a correct hypothesis? What happened when students found out, that they did not get the results they expected to have? How quickly did they begin to doubt that there might be something wrong with the batteries? What did the students do then? Did they ask you for new batteries? Did they throw the old one into the waste deposit basket? Did they just "forget" the old battery on the table and take a new one? Did they ask you what they should do with the old batteries?

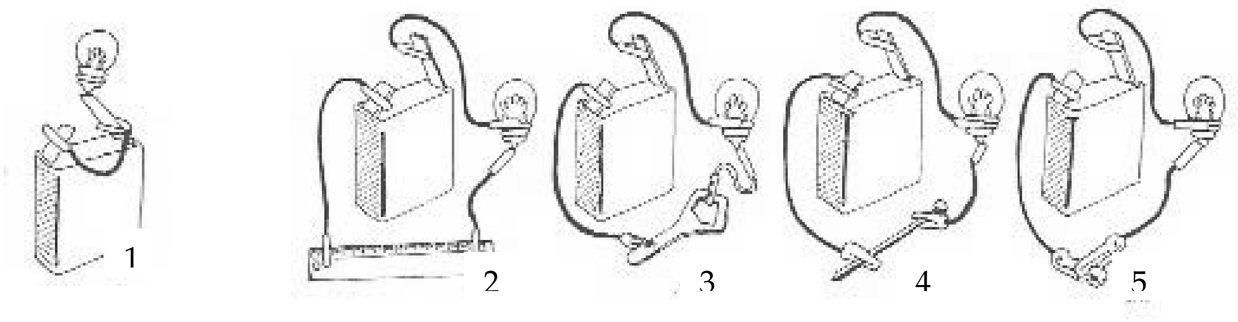
Litterature

Bader, H. J. & Kloss, M. 1992. Trennung von Kunststoffmischungen durch selective Lösenmittel. *Chemie und Schule 4, 2-25.*

Experiment E2: TESTING BATTERIES

Closed electric current circuit.

Students' preconceptions
First we gave students the following figure (Fig. 6).



Yes No Yes No Yes No Yes No Yes No

Fig 6 You should find out in which cases you can get the bulb to glow

There are five different examples in the picture. Look at them carefully. **Circle yes if you think that you can get the bulb to glow in the system and no if you think it will not!**

After we have tested students former knowledge (checked their preconceptions), we can let them go through all different cases presented. They can build up the experiments as shown in figure 6 and check their knowledge by doing a small investigation.

Problem
In which cases (fig 6) is the bulb really glowing?

The aim of this laboratory activity
The main aim in this study is to find out what students will do when they discover that eventhough they are sure that they should get the bulb to glow, they will not. It is because there is also an old battery, which no longer works (or an old bulb).

We will follow students working and giving them advice when it is asked for, but not formally. We reserve a wastebasket for batteries in the classroom and another basket (just an ordinary one). We will mark down what students do: if he/she asks the teacher where to put the used battery, just throw it into the waste basket or leave it among the others and take another battery.

Equipment and materials available
* one battery
* one bulb

* two wires
* a plastic ruler
* a nail
* a key

Procedure
Just follow the information obtained from figure 6 and carry out the experiments one after another.
Mark down the results under each picture, but do not take away your previous answers.

This experiment was used when 12-year-old pupils were studied.

Results and discussion
In how many cases did the students make a correct hypothesis? What happened when pupils found out, that they did not get the results they expected to have? How quickly did they begin to doubt that there might be something wrong with the batteries or bulbs? What did the students do then? Did they ask you for a new battery? Did they throw the old one into the waste deposit basket? Did they just "forget" the old battery on the table and take a new one? Did they ask you what they should do with the old battery?

When we studied 13- and 16- year-old students, experiment 3b or 3c was used.

Experiment E3a: REACTIVITY OF METALS

The following experiment was used when we studied 13 and 16 years old students (Asunta & Little 1995) .

Background

There are certain characteristics that we attribute to metals and others that we consider typical of non metals. In the last experiment (Metal or Non metal?) you attempted to classify elements as metals, non metals and metalloids on the basis of their physical and chemical properties. What you found was that there were differences even between elements that clearly belong to the same classification. For example, iodine has the shiny appearance that we normally expect of metals, but otherwise it is unquestionably a non metal: it won't conduct electricity, it isn't malleable, and it is unreactive toward both copper(II) chloride and hydrochloric acid. On the other hand, while magnesium, zinc, and aluminium all react with hydrochloric acid, tin and copper do not. In other words, the metals differ in their reactivity; we say that some metals are more active than others. In this experiment it will be your task to determine the relative reactivities (or, activities) of several metals.

When metals form compounds, they do so by becoming positive ions (cations); this involves loss of electrons (loss of electrons is called **oxidation**). By regaining these electrons, the cation returns to its neutral, elemental form (a gain of electrons is called **reduction**). Because of the differences in the make-up of their atoms, some metals lose electrons easily, while others do so only with difficulty. **Active metals** (ones that form compounds easily) hold their outer electrons very weakly, so it is easy for some other species to take one or more of these electrons from the metal atom's outer energy level. **Inactive metals** are ones that do not react readily to form compounds; they hold onto their electrons more tightly, so are not easily oxidised.

When an active metal is brought in contact with the cation form of a less-active metal, one or more electrons transfer from the active metal to the less-active ion. Thus, for active metal X and less-active metal Y, we could expect reactions like the following.

$X + Y^{+} \text{---->} X^{+} + Y$ (one electron transferred)
$X + Y^{2+} \text{---->} X^{2+} + Y$ (two electrons transferred)

If, on the other hand, the more active metal is present in ion form, while the less-active one is in the elemental state, nothing will happen.

$Y + X^{+}$ ----> NO REACTION

In other words, ions of less active metals (like Y, above) can oxidise (take electrons from) the neutral atoms of more active metals (such as X), but not the other way around; ions of the more-active element will not oxidise atoms of the less active element.

Safety hazards
Safety goggles must be worn at all times in the laboratory!

Procedure

Several metals will be tested for their relative activity. The metals to be compared are aluminium, copper, iron, magnesium, silver, and zinc. [Note: Silver is quite expensive, so it will be tested only by your teacher as part of a class demonstration following the rest of the experiment; you will test the other five yourself]. You will do the tests by placing samples of the metals in solutions containing the cation form of each of the other metals.

Put a single piece of one of the metals in each of four different wells of your 24-well test plate, then drop each other metal solution on separate pieces of the metal being tested, noting cases in which a reaction occurs. Use just enough of each solution to cover the metal piece. Quite often, the only sign of reaction will be a darkening of the metal surface, so careful observation is a must. It also sometimes happens that reactions are slow to occur; for that reason, you will want to wait at least four or five minutes before you decide that nothing happened. Proceed in this way until all five metals have been tested with solutions of each of the others. All solutions are 0.2 molar, and all the metal pieces have been freshly cleaned of any oxide surface coating.

Cleaning up

You will find a large bucket or jar with a sieve over it. Use a wash bottle to rinse solutions and bits of unreacted metal into the sieve. You may need to use forceps or a small spatula to dislodge some of the metal pieces. Your teacher will handle disposal from there, or she/he may assign disposal to one or more members of the class as a special project.

Conclusions

1. The metal that reacted with the greatest number of cation solutions is the most active metal you were testing; which one is it?

2. The metal that reacted with the fewest cation solutions is the least active; which is it?

3. Rank the remaining three metals, so that you wind up with a list of the five metals in order of decreasing activity (most active first).

4. Your teacher will demonstrate the reaction that occurs when copper metal is placed in a solution of silver ions. Describe the reaction and use your observations to place silver in its proper spot on your activity list.

5. (Optional) For those cases in which a reaction was observed, write the equation for that reaction. You can look up the charges for the various metal ions in your book. Remember that the number of electrons lost by one kind of atom must equal the number gained by the other, so the total charge on the left side of the arrow must be the same as the total charge on the right side.

REACTIVITY OF METALS
Teacher's Guide

Introduction

This experiment is pretty standard in concept and approach. It employs the concept of oxidation and reduction. The redox concept is so important that it is worth mentioning whenever appropriate, and its inclusion does not mean that we have to teach things like how to balance redox equations.

The Procedure indicates that you will do a demonstration using silver nitrate and copper wire. Admittedly, silver nitrate is expensive, but so much is to be gained by its use here that it can be considered cost-effective, if not economical. The demonstration is simple but it should not be done until after the students have completed their portion of the experiment and returned to the classroom for the post-lab discussion. Help the class come to a consensus concerning the least active and most active metals; the least active will be copper. There may well be ties for the middle spots, especially if the aluminium and iron were not thoroughly cleaned right before the experiment.

For the demonstration, a coil of copper wire (0.5 mm to 1,5 mm diameter) is made by wrapping the wire around a pencil, then the coil is suspended in a tube containing the silver nitrate solution. A layer of mossy, dark material begins to grow on the wire; this soon takes on hints of shiny crystals of silver metal, and the solution starts to take on a blue colour, indicating the presence of copper ions in solution. This proves that silver is even less active than copper, so it gets the bottom spot on the students' lists. For the best effect, make the coil just long enough to extend to slightly below the middle of the solution; the crystals that form below the coil over a period of a few hours are much nicer than the ones attached to the wire. The tube can be left on display for months.

Equipment
* small pieces of aluminium, copper and zinc
* 150 mm test tube, fitted with one- or two-hole stopper
* 20-30 cm copper wire (diameter 0.5 - 1,5 mm)

Chemicals
* 3.76 g aluminium nitrate, $Al(NO_3)_3{\cdot}9H_2O$
* 1.70 g copper(II) chloride, $CuCl_2{\cdot}2H_2O$
* 4.04 g iron(III) nitrate, $Fe(NO_3)_3{\cdot}9H_2O$
* 2.56 g magnesium nitrate, $Mg(NO_3)_2{\cdot}6H_2O$
* 0.85 g silver nitrate, $AgNO_3$
* 2.98 g zinc nitrate, $Zn(NO_3)_2{\cdot}6H_2O$

Preparation of solutions and samples
All solutions except silver nitrate are 0.2 M ($AgNO_3$ is 0.1 M). $Cu(NO_3)_2$ (aq) does not react well with aluminium, so $CuCl_2$ is used instead. Amounts given are for 50

ml of solution. Add the mass indicated to 50 ml of distilled or deionised water in a beaker.
Store silver nitrate solution in an amber glass bottle.

Cleaning up
The Procedure refers to sieves or strainers for collecting the unreacted bits of metal before they can get into the drain. An alternative is to line one or more of your sinks with fiber glass window screen; it's inexpensive, easy, and disposable when it gets too clogged, but it may teach students to discard things in the sink which don't belong there.

Answers to questions
1. Magnesium reacts with all four other metal solutions, so it is the most active (most easily oxidised).

2. Copper reacts with none of the other four, so it is least active.

3. Zinc should react with all except the magnesium; iron will only react with copper(II) and maybe aluminium ions, and then only if the wire is freshly cleaned - reaction is not rapid; the only reaction for aluminium will be with the copper(II) chloride. Thus, the order of decreasing activity is: Mg > Zn > Fe > Al > Cu. (Obs. Aluminium should rank #2, right behind Mg and ahead of Zn, but it always seems to ranked equally with Fe - we assume it is a matter of not fully cleaning off the outer layer of Al_2O_3).

4. Students should not only recognise the growth of the silver crystals, but should also see the blue colour. Final order: Mg > Zn > Fe > Al > Cu > Ag.

Experiment 3b: REACTIVITY OF METALS

The teacher gave the students the following problem to solve:

You should examine metal reactivities.
You have following different metal samples:
Cu- ribbon
Fe-powder
Iron nail
Mg-powder
Zn- chips

Examine what happens when you put a small amount of these metal samples in the reaction tube and put a few drops of hydrochloric acid (HCl) or sulphuric acid (H_2SO_4) in the 20 ml test tube. Write down what you observe. Determine then which one of these metals is most reactive! Put them in order: most reactive→ less reactive.

Observations:
The teacher asked what happened in each case /and students answered:
Cu+ H_2SO_4 / no reaction
Fe + H_2SO_4 / a light reaction
Iron nail + H_2SO_4 / almost no reaction
Zn + H_2SO_4 / some reaction
Mg + HCl /vigorous reaction
Cu + HCl /no reaction
Fe + HCl / reaction
Zn + HCl / reaction

After students had finished, they asked what to do with the residues. This laboratory session was videotaped. However, as mentioned in the methodology part, the videotapes did not have very much value in the final analysis. In this case it supported the observation.

Experiment 4: BEATING HEART

Procedure
NB. When carrying out this experiment, you should use safety classes all the time and rubber gloves until as you have finished the experiment.

Instructions
1. Pour a drop of mercury on a clock-glass and put some drops of 6 M $H_2 SO_4$ over it so that the mercury drop is covered with sulphuric acid. Add 1 ml 0.1 M $K_2Cr_2O_4$ solution to this mixture .
Put an iron nail on the clock-glass so that it will be in contact with the mercury. Add slowly 0.5- 2.0 ml 18 M H_2SO_4 over the mercury drop and stop adding it as soon as the drop of mercury starts beating. Beating can last hours if the nail stays still.

The main aim of this study is to find out what the pupils will do during and after this laboratory session. Will the students be worried whether they can use potassium dichromate solution because it is very harmful to nature?
Do they ask what to do with the mercury after the laboratory session?
Do they ask how to destroy the acidic solutions? etc.

Experiment E5: SYNTEHISIS OF SUPERBALL

Procedure
NB. When carrying out this experiment, you should use safety classes all the time and rubber gloves until you have finished the experiment and cleaned the equipment.

Instructions
Your teacher will give you 10 ml sodium silicate in a 100 ml beaker. Add 5 ml ethanol to the beaker slowly and mixing it all the time with a glass rod. Using rubber gloves, take this thick mixture into your hands and make a ball from it. Wash this ball well under tap water. Try the elasticity of the ball.

Silicon has an ability to form compounds that have plastic properties. The aim of this study is to find out what the students will do during and after this laboratory session. Discuss with students what they will do with the waste -in this case the superball - after they no longer play with it. Do they actually think it is waste at all? Would they like to take it home? Would you allow that?

APPENDIX 4
An example of an evaluation report form

The laboratory activities carried out (when this report form was used):
1. Electrolysis (E1)
2. Testing batteries (E2)

The form of the observation report for Chemistry teachers :

Background information

Date of observation: ____________ Time of observation______________
Number of students in room___________ Number of adults in room___________
Adult who is in charge of teaching :
Chemistry Teacher ____Student Teacher ____ Researcher_____
Adult who conducts the observation:
Chemistry Teacher _____ Student Teacher_____ Researcher_____
Laboratory activity carried out:____________________

General Questions/ Observation notes varied depending on experiments

1. During the teaching period before the laboratory activity starts, is there any discussion on recycling?

2. Does the teacher in charge mention that there are different wastebaskets available in the classroom?

3. Did the teacher discuss with the students what they should do with the old batteries?

4. What did the students do when they found out that some batteries or bulbs are not working?

5. Did the students discuss the decisions they were going to make or made with their partner or with other students?

6. How many students had batteries that did not work? ___

7. Mark down:
a) how many students dumped the old batteries in the ordinary waste basket ___
b) how many students noticed the waste basket reserved for batteries ___
c) how many students asked the teacher what to do ___

d) how many students just changed the batteries and left the old ones among the others on the teachers table ___

Other observations during the laboratory session (you can continue on the other side).

APPENDIX 5

Teacher's interview

Background information

Name of the teacher and position
School where he/she is teaching
How many years have you been teaching at school?
Your main subject (at University)? / Degree in Chemistry
In which grades do you teach?

Questions concerning teacher's environmental responsibility

1. Do you think that you are an environmentally concerned teacher?
2. How do you think it affects your teaching?
3. When you carry out some laboratory experiments, do you usually tell students what to do with the waste they will get?
4. Do you tell your students how harmful the wastes are?
    - For example, have you discussed recycling of batteries?
    - Have you discussed what liquids and substances can be dumped in the lavatory?
        a) Because they may stop up the pipes.
        b) Because they may be dangerous for nature or they may end up in the plants that people eat, or in the air, etc.
    - Have you discussed recycling metals?
5. Do you reserve different wastebaskets available in the laboratory for students to use?
6. Do you tell your students about environmental problems of today? Do you usually open the discussion concerning, for example, the environmental problems that have explained in some paper, or do the students start conversation about the subject?
7. Do you tell your students how chemistry can help to solve these problems (or make them smaller)?
8. Do you try to teach that chemistry mainly solves environmental problems - not causes them?
9. Do you in you own personal life act as an environmentally thinking person: sort waste, recycle, use compost, etc.?
10. Does it depend on convenience how you act when environmental questions are concerned?
11. Could you give some examples of your work in the field of environmental education?