Ethical and normative reasoning on climate change
Conceptions and solutions among students in a Chinese context

Li Sternäng
To Ola and Jacob
Abstract

Previous research in environmental education and learning has mainly concerned students’ understanding of natural scientific knowledge, whereas research on the influence of other knowledge in learning environmental issues is marginal. Also, the interest in most studies investigating students’ natural scientific knowledge has been to capture constraints in students’ understanding, hence investigations of students’ meaning making are rare.

The main objective of this thesis was to explore individual students’ reasoning regarding climate change, and the influence of knowledge on their reasoning.

In Study I, students’ conceptions of the enhanced greenhouse effect (EGHE) were investigated. The results showed that students incorporated different pieces of information from different problem areas into the conceptualization of the EGHE. Setting up causal links between diversely different pieces of information seems to be a way to make meaning, and thus a necessary step in the learning process. Study II is an investigation of students’ solutions to climate change. The results indicated that students contextualized problems and solutions by addressing the individual(s), where the individual(s) was either “myself” or “someone else”. The different notions of the individual(s) became crucial as the students’ views of the environment, as well as society, changed according to the different contexts. To further study students’ conceptions of “me” and “others”, Study III examined students’ conceptualized solutions to the dilemma between economic development and mitigating climate change. The findings suggested that students’ conceptualized nature as a “box” of resources, and that economic development would sustain and improve nature. Therefore, the dilemma between economic development and mitigating climate change or dealing with environmental problems did not exist. Results from all three studies were discussed with respect to theoretical implications.
Key words: alternative framework, climate change, conception, contextualization, decision making, economic development, environmental education, intentional analysis, learning, meaning making, moral reasoning
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List of studies


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Introduction

The present thesis focuses on exploring students’ conceptions of and solutions to climate change — one of the most prominent environmental problems. The studies included in this thesis were conducted at Green Schools in China. In Study I, students’ conceptions of climate change was examined in relation to conceptual change and development. In Study II students’ conceptions of and solutions to climate change were studied. In Study III, students’ solutions to the dilemma between economic development and coping with environmental problems were investigated. In the following, relevant key background information, pivotal theories, and concepts used in the thesis are summarized.

Climate change

In 1998, Mann, Bradley, and Hughes published the famous “hockey stick graph”. The hockey stick graph indicated that during the last 1000 years, the average temperature on the northern hemisphere had been steady until a sudden upsurge appeared around 1900 which corresponds closely to the time when humans began mass productions of commodities based on fossil fuels (e.g., oil, coal, and natural gas). The hockey stick graph was highlighted in the Intergovernmental Panel on Climate Change (IPCC) report (2001) (Figure 1), and is now widely referred to in scientific literature.
The last 100 years saw a large-scale use of fossil fuels for the production of commodities, running vehicles, generating electricity, and household usage. This has contributed to a sharp rise of greenhouse gases. Greenhouse gases mainly include carbon dioxide, methane, and nitrous oxide (IPCC, 2007). Carbon dioxide (CO$_2$) emission is believed to be one of the most important contributors to global warming, and thus climate change.

Climate change is a negative environmental externality with long-term global effect. Scientists point out that the consequences of climate change may become irreversible and catastrophic if they surpass certain thresholds (Rockström et al., 2009). The projected impacts of climate change cover areas of, for example, food, water, ecosystems, and extreme weather events (IPCC, 2007). Even though scientists suggest different thresholds, or boundaries of carbon emissions, implying different scales of actions to mitigate climate change, they concur that delayed actions are not only risky (Rockström et al., 2009), but also costly (Nordhaus, 2009; Stern, 2008).
Given that climate change is a global problem threatening mankind, a strong global agreement is more than necessary. However, the vehement debate during Copenhagen climate conference of 2009 further revealed the complexity of the problem. One focal disagreement concerns the allocation of responsibility between developed and developing countries. Developing countries insist that developed countries are primarily responsible for the consequences of climate change, whereas developed countries urge developing countries, especially four large developing countries (known as “Basis Four”: China, India, Brazil, and South Africa) to reduce emissions of greenhouse gases considerably. China is the largest developing country and emerging as one of the largest economic powers. However, China is now facing an enormous challenge, i.e. the dilemma between economic development while dealing with deteriorating environmental problems and mitigating climate change. Globally, China has become the largest greenhouse gas emitter, and needs to face up to this problem. Domestically, there are still a large number of people struggling for livelihood, and thus rapid economic development is needed. Against this backdrop, the present thesis is set in China to study youth’s understanding and reasoning on climate change. The assumption is that although the dilemma between economic and environmental development is more pronounced in developing countries, and certainly in China, this is a problem facing all countries in the world.

In the following, Chinese ideology concerning development and the environment, along with environmental education in the Chinese context are summed up.

Chinese context

Before the end of 1970s, during the time of Mao Zedong, China closed the door to the outside world, adopting a centrally planned economy as opposed to market economy. In sum, it can be said that the entire Chinese nation was guided by and thus pursued two doctrines: “mankind will definitely conquer nature”, and “however bold mankind is, however productive nature is” (Wang, 2005). The implication of these two doctrines is that nature is seen to be completely at service for humankind. Immediately after the time of Mao in the post-revolutionary time, the Chinese administration
pursued a policy of sacrificing the environment for economic development by implementing industrialization that relied heavily on fossil fuels, in particular highly polluting coal, without emission control (Gardner & Stern, 2002; Karasov, 2000). One direct consequence, according to a report in 1998 by the World Health Organization (WHO), was that of the ten most polluted cities in the world, seven cities were found in China (WHO, 2005). Today, China is developing at a speed that has surprised the world. Many economic achievements are made and personal materialistic dreams are realized. However, the environment has also been deteriorated at an unprecedented rate. The current official socio-economic ideology is indicated in the concept of scientific development, meaning a balance between economic growth and the environment to ensure a sustainable development and eventually a harmonious coexistence of man and nature (Fewsmith, 2004). However, in implementing this concept, there seems to be an overconfidence in scientific solutions, believing that science and technology can solve all environmental problems (Xiao, 2003).

Though there are large socio-economic differences regionally, especially between urban and rural regions, teenagers of China in general live in an age of enormous change, materialistic improvement, and economic worship. Talking about materialistic dreams among the teenagers has become a rule, not an exception. The Beijing area, in which the present thesis was conducted, is one of the most developed areas in China, though big rural and urban differences exist in the Beijing area too.

The dilemma between economic development and dealing with environmental problems is especially pronounced in China. Further, many years of rapid economic development has greatly aggravated the environment. How is the Chinese education system responding to this challenge?

China held the first environmental education conference in 1992. By the mid 1990s, media attention to and public debate about deterioration of the environment had urged state leaders in China to discuss how comprehensive environmental education could be integrated into the school curriculum (China’s Environmental Protection Agency & China’s Education Commission, 1996). Since 2001, the National Ministry of Education has initiated a nation-wide...
reform on the curriculum of the country’s primary and secondary schools. One of the top priorities is to enhance environmental awareness amongst the country’s younger generations. For this purpose, China’s Green School program was initiated in 1996. Green Schools have, since then, become important places to implement and highlight environmental education. Now there are over 16 000 Green Schools across China (Lin & Ross, 2004).

Green Schools is a long-term international program, focusing on environmental management and environmental education. The aim is to foster students with environmental values and behaviour (Wu, 2002). The model of Chinese Green Schools involves the functions of administers, teachers as well as students, emphasizing the integration of hands-on, research-based interdisciplinary environmental content and learning activities (Yu, 2003; Zhang, 2004).

Research on environmental and climate change education

Environmental education has attained more and more importance since the late 1960s as a response to the degradation of nature. However, environmental education does not normally take place in a separate discipline, but is penetrated in different disciplines. In China, according to the national curricula, environmental education is infiltrated in geography, biology, and Chinese language. This indicates that environmental education is not solely about ecology, it has also cultural, economic, social and human dimensions. Hart (2007), in reference to Huckle, described environmental education in the following:

“…all such definitions of environmental education or sustainable development rest on ethical foundations that are assumed to be about balancing four sets of values—environmental protection, quality of life, intergenerational equity, and intragenerational equity” (p. 691).

Research on environmental education has developed substantially since the 1990s. Reviews (e.g., Hart, 2007; Rickinson, 2001, 2003, 2006) show that the amount of empirical research on environmental
education is considerable. However, in contrast to the breadth and complexity of environmental education, empirical studies are characterized as being homogeneous: “quantitative in nature and positivist in foundation” (Rickinson, 2001, p. 216). Rickinson (2001, 2003, 2006) reported that most studies are conducted quantitatively as pre- and post studies, and the majority of studies are about learners (e.g., how many students understand a certain concept correctly) instead of learning, and they are mostly about learning outcomes, as opposed to learning processes. A common conclusion of most research studies is that the level of students’ factual knowledge is low. For example, much of the research shows that students have erroneous ideas and “misconceptions”, and their environmental knowledge and attitudes need to be altered through educational interventions (Rickinson, 2001, 2006). In short, reviews on environmental education research show that the influence of science education in environmental education research is strong in that foci are on students’ environmental knowledge and learning outcomes based on quantitative data. Learning processes have generally been neglected. In addition, researchers tend to be reluctant to engage with learning theory (Dillon, 2003; Rickinson, 2001; Rickinson, Lundholm, & Hopwood, 2009).

Recent years has seen many emerging studies that move away from the focus on students’ factual knowledge, and begin to investigate students’ environmental attitudes and behaviour (e.g., Boyes, Skamp, & Stanisstreet, 2009; Boyes, Stanisstreet, & Zhang, 2008; Kilinc, Stanisstreet, & Boyes, 2008). However, most research studies conducted in this area are characterized by a predominance of a survey-generated nature (Rickinson, 2001), derived from questionnaires with predetermined answer patterns assuming to mirror students’ thinking. Students’ reasoning is not elicited. Consequently, more research on students’ reasoning in their own right is needed. Numerous studies have shown that learners are not passive recipients of knowledge. Instead, they bring their experiences, their interpretations of the subject matter, and their values, emotions and moral judgment into the learning process. Thus learning can be described as a highly individualized enterprise (Halldén, 1988; Halldén, Scheja, & Haglund, 2008; Rickinson et al., 2009). Rickinson et al. (2009) have presented and summarized research on environmental learning, describing it as an “emergent research topic”. Environmental issues are often controversial issues, and the
challenges for learners are not solely regarding scientific knowledge. Rickinson et al. (ibid) showed that affective factors, for example, emotions, values, motivations, and ethical reasoning often pose similar challenges as scientific knowledge for students. They also showed that students’ engagement in the learning process is largely affected by their perceptions of the relevance of a certain environmental topic to them. Moreover, students and teachers’ different viewpoints can also pose a challenge in the learning process.

Climate change has undoubtedly become one of the most interesting topics for researchers of environmental education and learning. The goals of climate change education and learning are not solely to teach students natural scientific knowledge. Most importantly, students are expected to form an environmental awareness and change their behaviour as a result of instruction. However, research on climate change education and learning has been focusing on investigating students’ natural scientific knowledge (e.g., Andersson & Wallin, 2000; Areskoug & Ekborg, 2004; Batterham, Stanisstreet, & Boyes, 1996; Boyes & Stanisstreet, 1993; Boyes, Stanisstreet, & Zhang, 2008; Dove, 1996; Francis, Boyes, Qualter, & Stanisstreet, 1993; Jeffries, Stanisstreet, & Boyes, 2004; Lester, Ma, Lee, & Lambert, 2006; Mason & Santi, 1998; Rye, Rubba, & Wiesenmayer, 1997). Similar to the trend in environmental education research described above, most studies on climate change are conducted with quantitative methods to show the effect of certain educational programs, whereas studies on students’ reasoning are few.

Learning as contextualization

In the field of research on learning, conceptual change has emerged as the dominant description of learning, implying that learning can be described as a process in which common sense notions of the world are replaced by scientifically accepted ways of conceptualizing the world (Posner, Strike, Hewson, & Gertzog, 1982). Critics of such a view have pointed out that learning is not a matter of replacing less qualified or naïve conceptions of phenomena in the world, but is rather a question of understanding in what situations and within which genres different knowledge is useful and appropriate, and learning is thus seen as a process of contextualization (Caravita & Halldén, 1994; Halldén, 1999; Halldén et al., 2002; Halldén et al., 2007; Halldén et
al., 2008; Lundholm, 2004a, 2004b; Österlind, 2005; Petersson, 2005; Wistedt, 1994;).

Viewing the difficulty in learning as a problem of contextualization implies that it is improper to label a student’s understanding alternative to scientifically proved explanations as “misconceptions”. Rather, more attention should be given to students’ understanding in relation to contexts.

It was more than 40 years ago that Belanger (1969) criticized that most studies on concept learning reported students’ deficiencies in relation to scientific way of explanations, whereas few studies explored students’ understanding and reasoning. Research studies engaging in reporting students’ poor performance is still overwhelming, and studies on students’ reasoning in their own right are still marginal in number and size.

Empirical studies reporting students’ poor performance often generate results by taking what students say for granted, without considering interactional as well as wider institutional and cultural settings. Paper-and-pen tests, for example, can be regarded as examples where students’ competences are judged in a de-contextualized way according to what students write. Jakobsson, Mäkitalo, and Säljö (2009) pointed out that there is a danger in studies and tests conducted in this fashion in that students’ real competences are underestimated (see also Halldén et al., 2008). Since this line of research often reports what students cannot do, students’ own ways of understanding, their conceptions, have not been given enough attention.

Concept and conception

The comparisons between students’ poor performance, i.e. their so called “misconceptions”, and scientifically accepted ways of explaining, have ignored the difference between conception and concept. Entwistle (2007) discriminated that concept is the authoritative description of objects and behaviour that share the same defining features, and conception indicates students’ different ways of thinking about a phenomenon. Thus, a concept is found in scientific textbooks, papers, and debates, and thus outside a person’s mental entity (Larsson & Halldén, 2010). Conceptions are students’
idiosyncratic ways of understanding. They are related to personalized theorizing and hypothesizing of individuals (Gilbert & Watts, 1983).

Therefore, when studying students’ understanding of a phenomenon, it is their conceptions that are in focus. In this thesis, the research interest is students’ conceptions relating to different aspects of climate change. Study I concerns students’ conceptions of the enhanced greenhouse effect (EGHE), with a focus on displaying students’ processing of information, which can be regarded as mirroring the construction of a conception. Study II is about students’ conceptions of solutions and actions against climate change. Study III focuses on how students conceptualize the tensions between developing the economy on the one hand, and protecting the environment and mitigating climate change on the other. Students’ conceptions of nature and economy, as well as their relationship are central foci.

The distinctions between concept and conception may lead to the conclusion that it might be too hasty and misleading to say that students do not understand or that they have “misconceptions”. Rather, it might be more appropriate to talk about what students understand. This argument is congruent with Driver and Easley (1978) who have made a distinction between “misconceptions” and alternative frameworks. According to Driver and Easley (1978), “misconceptions” apparently denote an incorrect understanding of scientific concepts and theories, whereas alternative frameworks are students’ “autonomous frameworks for conceptualising their experience of the physical world” (Driver & Easley, 1978, p. 62). Alternative frameworks result from students own interpretations of the physical world, based on their experience, and thus they are reasonable explanations from students’ perspectives.

Meaning making

Tasks and problems

The distinction between “misconceptions” and alternative frameworks is an important step towards understanding students’ meaning making in the learning situation. When students are given a learning task, they often end up interpreting it in different ways, thus working on different problems (Halldén, 1988; Lundholm, 2004a, 2004b, 2005; Österlind, 2005). A distinction between tasks and problems has been
made by Halldén (1988): a task is what the teacher wants the students to do, and the teacher gives the students an assignment in the form of a task. Problems are students’ interpretations of the task: i.e. what students assume that should be done. Therefore, students “transform” a task into different “problems”, and the “problems” perceived by the students thus vary.

**Cognitive-oriented and discourse-oriented resources**

To understand what *problems* students try to solve when confronting a task is to find out what *meaning* is ascribed to the task by students, thus investigating students’ *meaning making* in the educational setting. According to Halldén et al. (2008), a student’s interpretation of a task (as a problem to be solved) involves both his/her perception of discursive requirements and the actualization of his/her repertoire of knowledge. That is, in solving the problem perceived, certain notions and beliefs in his/her repertoire of knowledge are actualized as most appropriate according to his/her understanding of the discursive requirements. Therefore, during his/her meaning making process of a learning task, a student’s discursive resources (such as his/her perceptions of duties, norms, and opportunities) and cognitive resources (such as beliefs, wants, and abilities) are in play simultaneously (Halldén, 1999; Halldén et al., 2008).

**Contexts**

A fair inference to draw from the above is that conceptions are imbedded in contexts (Halldén, 1999; Halldén et al., 2002). Larsson and Halldén (2010) argued that specific conceptions are not of vital importance to bring forth conceptual change, and “attention should be given to the contexts in which conceptions are embedded” (p. 642). First, there is the conceptual context, which corresponds to the cognitive-oriented realm of resources discussed above. A student’s conceptual context involves his/her beliefs and understanding of, for example, a scientific concept (Halldén et al., 2008). The student’s conception of the scientific concept in question is often quite different from scientific accepted explanations. This can be because the student contextualizes the concept in question in a particular situation. Therefore, there is also a situational context, which corresponds to the discourse-oriented realm of resources. For example, the situational context may include the actual setting in an interview, such as the
interlocutors, their behaviour, language and other cultural tools. The situational context can also include a larger setting such as the cultural background. The situational context provides a student with cues that allow the student to actualize the kind of knowledge that is perceived to be proper.

**Integration and differentiation**

Conceptual contexts and situational contexts work together when a student tries to make sense of a large amount of information in the repertoire of knowledge in order to solve a learning problem. The student tries to relate diversely different pieces of information to one another, and thus create coherent models. This process is described as integration, and is an important step in the learning process (Halldén et al., 2008). However, conceptual change and development is not only based upon integration, but also upon the process of differentiation. That is, when the student realizes that the established coherent model cannot account for new information, some information will, therefore, be given up and new information will be incorporated into the coherent models. However, integration and differentiation are not totally separate processes, and they are in play simultaneously. Yet, in capturing a certain moment of learning, one is possibly more salient. For example, in Study I the process of integration was in focus.

**Moral reasoning**

In Study II, students’ moral reasoning regarding solutions to climate change were examined. Moral reasoning is not independent of content, audience, and situation (Carpendale & Krebs, 1992). This assertion is contrary to the traditional Kohlbergian model of moral reasoning, which claims that people’s moral reasoning progresses through a series of identifiable stages. Implications can be drawn from the Kohlbergian model that there are universal moral stages irrespective of content or situational aspects. Kohlberg seemed to claim that determining factors are internal as opposed to situational (cf., Carpendale & Krebs, 1992).

Neo-Kohlbergians have disapproved of the structural homogeneity of the traditional Kohlbergian model of moral reasoning. For example, Levine (1979) argued that in moral development new stages do not
displace but build upon the old ones and thus still encompass previous views. Harré (1984) advocated a theory of moral order instead of the Kohlbergian moral developmental stages, and thus expected moral judgments to be heterogeneous. This means that people make different moral judgments in relation to different dilemmas. This has challenged the Kohlbergian theory, which implies that moral reasoning is irreducible, and suggests instead that it is flexible across different situations. Moreover, Carpendale and Krebs’ (1992) empirical work indicates that culture and audience are important factors in moral reasoning.

In summary, neo-Kohlbergian research on moral reasoning encompasses different facets such as the role of culture, audience, and emotions. In addition, particular areas of one’s life experience are acknowledged to play an important role in decision making and character formation (Zeidler & Keefer, 2003). Thus, later research suggests a broader conceptualization of moral reasoning.

Decision making

Moral reasoning, along with personal values and emotions play important roles in students’ argumentation and decision making on socio-scientific issues (Fleming, 1986a, 1986b; Walker & Zeidler, 2007; Zeidler & Keefer, 2003), such as climate change. Study III reported on students’ conceptions concerning nature and society through decision making.

Kortland (1996, 1997) defined decision making concerning a personal or public issue as giving argued viewpoints and making reasoned choices among alternatives, which requires one’s judgment in terms of values. A small number of research studies on environmental education and learning have studied students’ decision making regarding environmental issues. For example, Jiménez-Aleixandre and Pereiro-Munoz (2002) investigated students’ decision making regarding a proposal of underground drainpipes across a wetland in order to clean sewage. They found that students’ decisions were not based on understanding and using scientific evidence. Rather, value judgments played a more important role. Similar findings were reported by Grace and Ratcliffe (2002). They indicated that when students made decisions about biological conservation, they drew more on values than biological knowledge and concepts. Ekborg
(2005) reported how science teacher students reasoned and decided on the use of heat from a local crematorium. She showed that the students mostly used emotional arguments and personal values, whereas scientific knowledge was only used to a very limited degree. Aikenhead’s (2003) review of research on humanistic perspectives in science curricula summarized that students rely more heavily on values than on scientific evidence when working with socio-scientific issues. Similarly, Walker and Zeidler (2007) emphasized that personal values, ethics, and social and political issues seem to be primary factors in students’ decision making.

Objectives of the thesis

Previous research in environmental education and learning has been insufficient since it 1) has mainly been about students’ understanding of natural scientific knowledge, while research on the influence of knowledge other than natural science is marginal, and 2) has mainly been about the extent and outcomes of their environmental knowledge as opposed to students’ reasoning and meaning making.

The overall goal of this thesis has been to study students’ reasoning on climate change, and the influence of knowledge in their reasoning.

Specific aims in the separate studies were:

1) To study students’ understanding of the phenomenon of climate change (Study I).
2) To study their proposed solutions to dealing with climate change (Study II).
3) To study students’ conceptions of solutions to the dilemma between economic development and mitigating climate change (Study III).
Methodology

Data collection for this thesis was conducted in five Green Schools for Study I and Study II, and three Green Schools for Study III, in the Beijing area in 2005 and 2006. The five schools were granted the title of Green School in 1998, 2000, 2004, 2005, and 2005 respectively.

Study I and Study II

Participants

The participants of Study I and Study II were 13-14 years old. Among 15 students studied, two of them (a boy and a girl) were chosen as examples in the text of Study I. Nine (four boys and five girls) were chosen as examples in Study II.

Interviews

The interviews were semi-structured, akin to Piagetian clinical interview (Piaget, 1929/1973), and they were conducted by a biology teacher at a university in Beijing. She was not a teacher to the students interviewed.

The two main interview questions were: What is the enhanced greenhouse effect (EGHE)? How do you think this problem can be solved? The results of the first question were reported in Study I, and the results of the second question were reported in Study II. Naturally many probing questions were asked so that students could clarify and elaborate on their points of view.

The interviews were conducted as group interviews. Three students from each Green School formed a group to be interviewed. This arrangement was to stimulate discussions among students themselves.
The interviewer acted like a moderator who posed questions to challenge what students had said or to let students explain their viewpoints. In addition, when students’ discussions were off-track from the interview objectives, the interviewer would pose questions to keep discussions by students pertinent to research objectives.

Study III

Participants

In Study III, the 12 participants were 15-16 years old (5 boys and 7 girls).

Role play

In Study III, the participants played the role of “board of judges”: four students of the same school formed one board of judges, and thus, there were three boards of judges altogether (from three different Green Schools). They were supposed to make a decision concerning whether or not a car factory should be set up near to a village with a coal mine resource.

The reason for assigning the participants the role of judges was to investigate their decision making when confronted with multiple alternatives. Role play is a methodology that is used to help students to understand more complicated aspects of real-life issues (Blatner, 2007). Students can become more involved and motivated to explore alternatives, and thus to develop skills of communication and decision making as well as problem solving (ibid.). Rogers and Evans (2007) reported that role play could enhance students’ learning and development due to the dimension of social interaction and negotiation. We assumed that role play was especially helpful for conducting Study III because the board of judges as decision makers could develop a better understanding of the dilemma when they were provided with different perspectives.

In Study III, the focus was on reporting interviews with the three boards of judges. However, other role players are worth mentioning: students played governmental leaders, ecologists, UN representatives,
and villagers. They held a debate concerning the pros and cons of the car factory proposal where different viewpoints were put forward. The participants of the present study (the board of judges) listened to this debate and they could also ask questions.

Interviews

The participants were interviewed twice: before and after the debate. During the pre-interviews, the main questions were: 1. Do you think a car factory should be set up or not? Why? 2. Does a car factory have any impact on climate change? After four weeks, the post interviews were carried out immediately after the debate. The main interview questions were: should a car factory be built or not? Why?

The same interviewer conducted the pre- and post interviews in Study III. Similar to Study I and Study II, students were interviewed as groups in Study III since students’ conceptions reflected through discussion were of interest.

Data collection

Study I and II were tape-recorded and Study III was both tape- and video-recorded by the interviewer and her assistants. The data material was first transcribed into Chinese and then translated into English by the author of this thesis.

Analytical methods

Intentional analysis

When students solve learning problems, they perceive the discursive requirements of the setting in which they are in, and actualize the repertoire of beliefs to evaluate which kind of knowledge fits the perceived requirements of the setting (Halldén et al., 2008). From such a perspective, in the analysis, students’ utterances were considered from a cognitive perspective focusing on students’ beliefs and desires, and they are also considered in relation to the interview
situations (e.g., the interviewer, group discussion), as well as the context at large (e.g., being a teenager in China). This rationale for explaining students’ utterances is based on von Wright (1971) who stated that in order to understand why a person acts the way (s)he does, it is necessary to ascribe meaning to his/her actions, and thus to view them as intentional. For a researcher, to interpret a student’s utterances (viewed as verbal actions) involves identifying the cognitive resources (e.g., beliefs, abilities, wants, and desires) as well as discursive resources (e.g., duties, norms, and opportunities) as these can be presumed to be apprehended by the student as well as the researcher (Figure 2).

![Diagram of analytical framework]

**Figure 2.** Analytical framework to understand utterances (Originally from Halldén et al., 2008, slightly adapted here).

This process of analysis is to rationalize the students’ actions into a good-reason-assay description. Such an analysis has been schematized as *intentional analysis* (Halldén, 1999; Halldén, Haglund, & Strömdahl, 2007; Halldén et al., 2008; Lundholm, 2003, 2004a, 2004b, 2005). By using intentional analysis, students’ utterances were
not taken for granted. Instead, they were put in an explanatory framework involving the deliberation of cognitive-oriented and discursive-oriented resources, which provide complementary perspectives in analyzing students’ utterances. With reference to these two different realms of interpretation, it is possible to find coherence and rationality in students’ utterances.

According to Halldén et al. (2007, 2008; see also Larsson & Halldén, 2010, Larsson, Haglund, & Halldén, 2011), researchers are obliged to discover coherence and rationale in students’ utterances. This argument is in line with Davidson (2001) who suggested that we have to optimize coherence in people’s utterances in order to understand them. Davidson argued that in order to understand other people’s utterances and behaviour, we should ascribe a great deal of rationality and truth in them. If we assume too much unreasonableness in other people’s utterances and behaviour, we undermine our capacity to understand what the unreasonable part is.

By adopting an intentional perspective in this thesis, the main interest in Study I was to seek for rationality and coherence in students’ reasoning. In Study II and III, students’ beliefs and desires, along with the interview situation and students’ background (e.g., from Green Schools and as teenagers in China) were considered in the interpretations.

The triangle model

The World Summit on Sustainable Development 2002 described the now widely used three “pillars” for sustainable development: social equity, environmental quality, and economic prosperity (Kates, Parris, & Leiserowitz, 2005). A growing consensus in the educational literature is that attention needs to be paid to their inter-relationships (Walshe, 2008). From a research perspective, it is of interest to examine how an individual, such as a student, reasons his/her position, along with other people’s positions in relation to the environment and the society. Lundholm (2008) proposed an alternative model for analyzing environmental and sustainability issues (see Figure 3). This triangle model was used as an analytical lens for coding of the data material in Study II and Study III.
The importance of the triangle model is that it represents three crucial aspects (individual, nature, and society) and their inter-relationships (individual and nature, nature and society, and individual and society) in relation to environmental issues. Individual focuses on students’ conceptions related to human beings in the face of environmental issues. Nature focuses on students’ conceptions of nature, for example, students’ conceptions of the EGHE (see Study I). Society represents students’ conceptions, norms, and values with respect to social, economic, political organizations and functions, as well as their conceptions of justice and democracy. The relationship of individual and nature includes individual’s conceptions of attitudes and behaviour that affect nature; nature and society includes conceptions about both societal effects on nature and nature’s effect on society. For example, the way institutional decisions and actions affect nature, and also institutional reaction to environmental problems, such as to climate change; individual and society focuses on how individuals are influenced by societal norms and how the formation of societal norms are affected by people.

In coding the data, the triangle model was used for identifying and describing what aspects and relationships students focused, or did not
consider in their discussion. For example, when students talked about the environment, it was coded as nature; when they talked about economic aspects, it was coded as society; when they talked about natural resources and economic development, it was coded as nature and society. Naturally, there was more detailed analysis, such as identifying what types of inter-relationships that were conceptualized by students. The purpose of using this model to identify different aspects and inter-relationships was to clarify different ways of reasoning about proposed solutions.

Generalization

One important aspect of the results of a study is their applicability or transferability. That is, to what extent can the results be generalized? Most researchers seem to agree that there are two types of generalization: statistical or empirical, and, theoretical or conceptual. Statistical generalization is mostly associated with quantitative studies and is based on the assumption that the samples of one study are statistically representative of a wider population (Draper, 2004). In contrast to statistical generalization, theoretical generalization is more concerned with developing theoretical principles, which can be more or less complex. Most researchers seem to agree that qualitative research is generalizable, but of a different type than quantitative research. Qualitative studies seek to understand phenomena in specific settings (Golafshani, 2003). Seale (1999) pointed out that qualitative studies can lead to general theoretical propositions. The rationale is based on logic rather than probability. Yin’s (1989) term “analytical generalization” followed the same reasoning as theoretical generalization in that it is not generalization to some defined population, but to a theory of the phenomenon studied, and the theory may have a much wider applicability than the particular sample being studied.

The studies included in this thesis can be seen to be in line with theoretical or analytical generalization. In Study I, the process of how a person’s repertoire of knowledge is actualized and restructured when dealing with a complex learning problem is analyzed. This process is an important step in learning, and is assumed to be applicable also to other people when dealing with complex problems. In Study II, students’ moral reasoning regarding solving climate change is
presented. The students’ reasoning introduced a general moral problem that has been reflected in the concept of “social dilemma” (e.g., Komorita & Parks, 1996). In Study III, students’ reasoning on nature and the economy also represents a common way of reasoning in general (as discussed later in the part of “Discussion”).
Summary of the empirical studies

Table 1. Overview of the studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of participants</th>
<th>Age</th>
<th>School</th>
<th>Data collection</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>15(2)</td>
<td>14</td>
<td>Two urban Green Schools</td>
<td>Semi-structured interviews</td>
<td>Intentional analysis</td>
</tr>
<tr>
<td>II</td>
<td>15(9)</td>
<td>13-14</td>
<td>Two urban Green Schools and one rural Green School</td>
<td>Semi-structured interviews</td>
<td>Intentional analysis, triangle model</td>
</tr>
<tr>
<td>III</td>
<td>12</td>
<td>15-16</td>
<td>Two urban Green Schools and one rural Green School</td>
<td>Role play and semi-structured interviews</td>
<td>Intentional analysis, triangle model</td>
</tr>
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</table>
The concept of climate change is characterized by complexity. It is not only a phenomenon in nature and an environmental issue, but also an issue that is of concern for society, thus a moral and economic issue (Chambwera & Stage, 2010). The focus of the present thesis is to investigate how students in the Chinese context conceptualize the complexity of climate change.

The results showed that students have touched upon the complexity of climate change in that they are aware that climate change is a serious environmental issue to which immediate actions should be taken, and also in that students’ solutions to climate change involved ethical as well as economic reasoning.

The objective of Study I was to investigate students’ understanding of the phenomenon of climate change. One of the challenges for students to understand the phenomenon of climate change is the many “speech genres” (Mäkitalo, Jakobsson, & Säljö, 2009) in which climate change is discussed. That is, different social groups and institutions communicate and discuss climate change in their own ways. In school in particular, the topic of climate change and other environmental issues are touched upon in several different disciplines. Therefore, climate change as a concept is embedded in diverse social settings in which different conceptual frameworks are used. For an individual student, it is probable that (s)he has assimilated a lot of diverse information about the phenomenon of climate change. The goal of Study I was to examine how students cope with the large amount of information related to climate change, and if students are aware that climate change calls for actions and solutions.

One conclusion drawn from Study I is that students are aware that climate change needs to be solved and immediate action needs to be taken. Study II went a step further by examining what type of solutions to climate change that was proposed by the students. The results showed that students attributed the causes of climate change mainly to factories and cars. They conceptualized solutions from a moral perspective by addressing the individual, where the individual was either “me” or “others”.

Students’ reasoning on “me” and “other” suggested that “me” should enjoy economic achievements, whereas “others” should care for the environment and probably not buy cars. Therefore, in Study III, this
was investigated further by examining students’ solutions to the dilemma between developing the economy on the one hand, and mitigating climate change on the other. In the following, the main findings of the three studies are summarized.

Study I: Learning as a process of integration: Students’ meaning making of the enhanced greenhouse effect

Climate change, along with other environmental problems has become an important topic for different institutions who also communicate about it in different ways. Students have thus assimilated a lot of information about climate change and other environmental problems from different sources. Against this backdrop, what are students’ conceptions of climate change, and how do they process their acquired knowledge?

Students of 13-14 years of age at Green Schools in the Beijing area were interviewed about the phenomenon of the EGHE (What is the EGHE?). Results of two students’ (Zhu and Hao) reasoning were presented, as their talks and ways of reasoning can be said to be representative of all the students interviewed. Importantly, by presenting excerpts from these two students’ reasoning, the aim was to give a thorough analysis of how students organize their knowledge when trying to solve a learning problem.

Students’ utterances were examined from an intentional perspective, focusing on coherence and rationality. The results showed that when the two students explained the phenomenon of climate change, they have incorporated and used a lot of information. Some information was related to climate change, some concerned evaporation and the tilt of the earth, and some was related to environmental problems such as pollution and the depletion of ozone layers. The students reorganized these diversely different pieces of information into coherent entities.

For example, Zhu’s modeling included the holes in the atmosphere, resulting from the depletion of the ozone layer. These holes made it possible for the sunshine to come in and heat up the earth; the heat could not escape into space because of the pressure from the atmosphere. The heat caused melting of icebergs, which is used to
keeping the earth cool enough. In Hao’s modeling, there were two “tops” of the earth — the Polar Regions. Pollutants rose up to the tops, destroyed and made holes in the ozone layer, and these holes of the ozone layers above the Polar Regions allowed more sunlight to reach the earth. The sunlight could not escape because the earth was wrapped in the atmosphere, like a blanket around the earth, and the spinning of the earth spread the heat to other parts of the world.

Zhu and Hao’s models of the EGHE are different since they have incorporated different pieces of information in their modeling. However, they are similar in that the two students re-structured diversely different pieces of information and constructed logical connections among them, thus creating coherent wholes. Even if these are wrong compared to scientifically accepted views of the EGHE, they make sense for the students and have explanatory value for them. They help the students to relate disparate pieces of information to one another, and thus solve some problems at the same time. Modeling coherent wholes, or integrating acquired knowledge, seems to be a necessary and important step in the process of learning.

One conclusion drawn from Study I is that although students incorporate information from various problem areas, and thus make some mistakes in relation to scientifically valid explanations, they know that climate change is caused by human activity (such as driving cars), and thus are required solutions. Study II further investigated students’ solutions to climate change.

Study II: Climate change and morality: Students’ perspectives on the individual and society

Climate change is a typical socio-scientific issue involving multiple perspectives and moral dilemmas. The seriousness of this issue has attracted many researchers in environmental education and learning. However, most research studies have only examined students’ natural scientific knowledge and compared it with scientific explanations (e.g., Andersson & Wallin, 2000; Batterham, Stanisstreet, & Boyes, 1996; Shepardson, Niyogy, Choi, & Charusombat, 2009), as opposed to investigating influence of knowledge from other areas.
An important goal of environmental education is to prepare students to become responsible citizens and to take pro-environmental action. However, research studies have indicated that there is a gap between environmental knowledge and pro-environmental action, i.e. environmental knowledge does not guarantee environmentally friendly behaviour (e.g., Grace & Ratcliffe, 2002; Kollmuss & Agyeman, 2002). Therefore, a growing body of research has also begun to acknowledge affective aspects, in which moral understanding is of particular interest in promoting action and preparing students for problem solving as responsible citizens.

The solutions conceptualized by students in Study II concern moral and normative issues: What should I do? What do I think is right or wrong to do? What matters to me? Students’ moral reasoning in relation to climate change was examined in this study.

Nine students from three groups (three in each) from three Green Schools in the Beijing area participated in the study. The study was based on semi-structured group interviews, and the interview questions mainly concerned causes and solutions to climate change.

In the analysis we used a triangle model (Figure 3) which includes three aspects (individual, nature, and society) and their inter-relationships (individual and nature, nature and society, and individual and society) of environmental issues as an analytical lens in coding students’ utterances. Thus, the analysis focused on identifying different ways of moral reasoning among the students and how this concerned the individual, nature, and society.

An intentional perspective was adopted when interpreting students’ utterances, with the purpose of focusing on students’ cognitive competences: their beliefs, wants, and abilities. The intentional approach also considers students’ perceptions of discursive/situational requirements, such as an interview situation, Green Schools, and Chinese cultural background. To bring cognitive-oriented and discursive oriented resources into an interpretive framework enables more valid interpretations of students’ utterances.

The findings of Study II showed that students attributed the causes of climate change to emissions from factories and cars, and that they dedicated themselves to finding solutions to climate change. The
solutions mainly concerned taking actions by the individual, where the individual was either “myself” or “someone else”. This brought forth two different ways of moral reasoning, depending on the individual as “myself” or “someone else”, resulting in different relationships and considerations for nature and society.

When the individual was “myself”, a student was likely to be more anthropocentric, which means that her/his personal needs and interests were emphasized, and prioritized, and the aspect of nature was not discussed and thus excluded. Additionally, the relationship between society and individual was pictured more harmonious in that society was thought to support the individual. On the other hand, when the individual was “someone else”, the students were more concerned with the environment and the aspect of nature. Moreover, the relationship between individual and society was emphasized, but the society was seen as executing punishment rather than being supportive.

Students’ reasoning of “me” and “others” raise an interesting question: should economic development be prioritized in order to satisfy people’s materialistic demands, or should mitigating climate change and protecting the environment be prioritized? Students’ reasoning on the dilemma between economic development and dealing with climate change or other environmental problems was investigated in Study III.

**Study III: Climate change and costs – Investigating students’ reasoning on nature and economic development**

To our knowledge, few studies have investigated students’ thinking with regard to issues and dilemmas concerning not only the environment, but human, societal and economic aspects as well.

In this study, the question of how students understand the dilemma between economic development and mitigating climate change was in focus.
Specifically, the aim was to explore students’ conceptions of economic development and the environment through decision making concerning a task that was assigned to them: the participants played the role of “the board of judges”, and were instructed to decide whether a car factory should be set up near a village with a coal mine or not. The details of the task included the pros and cons of setting up the car factory, with the former concerning mainly economic benefits and the latter mainly problems of climate change, hence a dilemma between developing the economy and mitigating climate change.

12 students aged 15-16 from three Green Schools (two urban and one rural) formed three boards of judges. Each board of judges was interviewed twice: before and after a debate on the topic of building a car factory.

The results of the study showed that students did not relate producing and driving cars and using coal for energy supply with climate change. Instead, for them, the focal aspect of the task concerned the development of the economy. In the pre-interviews, students decided to set up a car factory because developing the economy and social welfare were seen as most important. With regard to environmental problems, they suggested that they were inevitable, and even a necessary part of development, and that they could be solved by scientific and technological means.

In the post interviews, students disapproved of setting up the car factory due to various reasons concerning the feasibility of establishing a factory, such as source of capital, transporting, and selling. Thus, students changed their decision based on economic, as opposed to environmental considerations.

During the decision making process, students mainly drew on their understanding of nature and society (economic development), and the link between these two, along with their values. What is interesting to highlight is students’ focus on economic development. Economic development was seen as a prerequisite for sustaining the environment. Their conceptions of nature are also of interest: Nature was viewed as a resource “box”: static and restorable. When people need something, they can take it from the box, and simply return it later. Furthermore, students also suggested that to maintain or to sustain this box, developing the economy was a prerequisite because
through economic development people could fix the box and even make the environment better. Our conclusion drawn from Study III is that for these students there was no conflict between developing the economy and protecting the environment, and so, the dilemma indicated in the task simply did not exist.

Students’ static views of nature could be just a conceptual understanding, not a systemic understanding which takes a larger ecological system into consideration. It seems that students’ line of reasoning is congruent with the Environmental Kuznets Curve (EKC) hypothesis that environmental damage first increases in a country’s developmental process, but then decreases after certain income threshold is met (Heerink, Mulatu, & Bulte, 2001). This is problematic since nature is not a “box” that works in a static and linear way and climate change is a driver on a planetary level influencing ecosystems to change in ways that are irreversible. Furthermore, changing processes that are non-linear are difficult to predict, and hence negative consequences are unknown (Rockström et al., 2009).

However, students’ reasoning is in line with prevalent values and beliefs in the Chinese culture where a person’s success and identity is strongly connected to his/her economic status, such as owning a car.
Discussion

The influence of knowledge on students’ reasoning

Study I

Earlier in this thesis, it was summarized that research on environmental education and learning has been insufficient due to two main reasons: First, the majority of empirical studies have focused on examining students’ constraints in understanding. Second, research studies have focused on reporting the extent or scale of students’ knowledge (e.g. how many students have or do not have certain knowledge). A general picture drawn from research conducted along this line is that the level of students’ scientific knowledge is generally low, and students display a high level of confusion about the science of environmental issues, often characterised by persistent “misconceptions” (Hart, 2007; Rickinson, 2001, 2003, 2006; see also Jensen & Schnack, 2006; Tsevreni, 2011). Therefore, research studies have indicated a gap between students’ conceptions and scientifically proved views, and the research focus has been on comparing how “far away” students’ conceptions are from the normative ways of understanding, i.e. the scientifically accepted views. The problem that has been addressed has not been how students come up with alternative frameworks, but how students’ alternative frameworks act as obstacles for students to accept scientifically accepted views, and why it is so difficult to abandon them in favour of scientifically valid views.

Through a detailed analysis, Study I showed how students contextualize their acquired knowledge into coherent models, and thus form alternative frameworks of understanding climate change. By displaying how students process different pieces of information, this study has showed a part of the very process involved in conceptual change, which may mirror the emergence of a conception. Thus this study suggests an alternative way of investigating conceptual change.
Study II and Study III

When using the analytical lens adopted in the present thesis (Figure 3), it can be concluded that a general characteristic of the vast majority of research studies on environmental education and learning is their focus on students’ scientific knowledge regarding nature. The general underlying assumption seems to be that students need to have a lot of scientific knowledge in order to make decisions and act pro-environmentally. However, climate change and environmental issues are often complex issues including social, economic, and human dimensions. Jensen and Schnack (2006) pointed out that the dominance of scientism in environmental education and research, focusing often on students’ knowledge about the seriousness and extent of environmental problems, has not yet addressed the social perspectives and possible solutions which are open to a society and the individual.

Further, research also shows that there is no direct link between environmental knowledge and pro-environmental behaviour (e.g., Kollmuss & Agyeman 2002; Posch, 1993; Rajekci, 1982) and decision making (Aikenhead, 2003; Ekborg, 2005; Grace & Ratcliffe, 2002; Jiménez-Aleixandre & Pereiro-Munoz, 2002). Therefore, to discuss and make decisions when confronted with real-life issues, such as climate change, natural scientific knowledge is not enough. Additionally, the dominant trend of environmental education research reporting on the extent of students’ attitudes and behaviour, has not yet generated more detailed reasoning and learning at the individual level.

In comparison, Study II and III examined students’ reasoning on solutions to climate change and environmental problems, and how students draw on their social knowledge, revealing a reasoning that connects in particular to ethical and economic aspects.

In Study II, when students ponder over responsibility and action, they begin to consider who are “bad doers” and who are “good doers”. What should I do? What should other people do? Therefore, what is displayed in this process is students’ normative and moral reasoning in looking for solutions to climate change, where they reason differently regarding what “I” should do and what “others” should do. Students’ reasoning of “me” and “others” represents a social dilemma in which
self-interest is often in conflict with public interest. According to students’ reasoning, “others” should act in favour of the environment, but “I” should act in favour of my own interest. Thus, different “principles” for taking action are used, allowing themselves greater freedom and comfort, and implicitly suggesting that others will sustain nature through their actions.

In Study III, students’ reasoning on nature and economy, along with their inter-relationship was revealed: nature is like a box of resources to be used, and economic development can sustain the box. In this way, there is no conflict between developing the economy and protecting the environment. This reasoning is congruent with current Chinese ideology where ecomodernism plays a dominant role. These results, to some extent, conform to Study II in that though students are aware that carbon emissions should be reduced, they tend to reason that in the Chinese context (my country), we should focus on developing the economy at the moment, whereas other countries, probably, should act more in favour of the environment.

However, students’ reasoning is not unique from a global perspective. Most countries agree that something needs to be done and all countries would be better off if carbon emissions were reduced. However, it has been proved extremely difficult to reach an agreement regarding the reduction of emissions. Many countries expect other countries to take on more responsibility and action. Apparently, national interest is at odds with global interest. Many developing countries argue that developed countries bear a greater responsibility since climate change has been caused by the long-term historical emissions of developed countries with high level of per-capita emissions. China and many developing countries argue that their people should not be limited to a few basic “survival emissions”, while developed countries still enjoy high living standard with “luxury emissions”. For example, Chinese officials argue that the developed countries have been contributing to climate change for 200 years, while China has been doing so for only 30 years. They have pointed out that high per-capita emissions in developed countries are the main reasons for them to take more responsibility in combating climate change.

Therefore, climate change is not just a scientific problem which can be handled with natural scientific knowledge. It is more a problem of
how society can work together to solve it, which is urgent. Thus, students have introduced a general ethical question, which has been a hot and difficult political question around the world, not specifically a question for students in China.

Since students have introduced such a difficult ethical issue, a question is how to respond to this in education, and how to investigate this further. Reid and Scott (2006) argued an alternative visualization in environmental research to foreground more “sociologically emerging phenomenon” rather than “cognitively structuring one”. This thesis is perhaps an opening towards exploring students’ reasoning on climate change in the context of China, which is a more representative context of the tensions between economic development and environmental protection.

Implications for education

Study I

In this study, students’ potentiality and capability to contextualize their acquired knowledge in a particular way when confronted with a complex learning problem are illustrated. By this, the research is not to judge how successful or unsuccessful a student is in handling a learning task. Thus, this study moves away from “negative rationalism” (Rommetveit, 1978), where students’ deficiencies are highlighted. This has important implications for teaching since school education is focused on helping students to abandon “misconceptions” in favour of scientifically accepted views. However, with regard to environmental education, it is perhaps not the gap that is of interest. Rather, it is the way in which students are reasoning, which advocates a view that affects action which involves ethical and normative reasoning as is shown in Study II and Study III.

Study II and Study III

Since the emphasis in environmental education has been that of teaching scientific knowledge, students may develop an illusion that science is a panacea to all environmental problems. This is clearly shown in Study III where students have a strong faith that science and
technology, invented due to economic development, can deal with climate change and environmental issues.

While scientific knowledge helps students to understand the mechanisms of climate change and other environmental issues, there are also other dimensions, such as socio-cultural, economic, moral, and value dimensions which are important in learning environmental issues. These aspects need to be identified and addressed in education.

Concluding comments

This thesis shows that environmental education and learning is a complex area to investigate since scientific knowledge is not enough to empower students for problem solving now and in the future. Students’ reasoning with regard to social, economic, and moral dimensions is equally important.

Investigations about how students process their acquired knowledge and develop it are rare. Research on students’ reasoning with regard to their proposed solutions to climate change and environmental problems at an individual level is also rather rare. Studies often use pre-determined questions which are assumed to mirror students’ thinking, whereas the complexity of students’ reasoning is not always delineated. Methodologically, this thesis has adopted an intentional approach in examining students’ interaction with their repertoire of knowledge and the surrounding world. Such a perspective makes it possible to take the students’ reasoning seriously during the investigation, and to focus on their potentialities in learning.
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