ABSTRACT
Within Education for Sustainable Development (ESD) various skills and knowledge are discussed, both in policy documents and in research reports. Therefore the aim of this study is to investigate what skills and knowledge students actually use in discussions related to sustainable development. Groups of students were observed when they worked with a task about Ecological footprints, within the subject Science studies. The subject is mandatory in all programmes in the upper secondary school and is about science for citizenship. Group discussions were audio recorded and transcribed. A content analysis was performed and thereafter a specific search for utterances which could be interpreted as critical thinking, conflicts of interests or ability to use cause and consequences.
Results show that the students have ideas about “environmentally friendly behaviour” and shows interest in equity issues. There was some science in the discussions, for example food-chains and population growth. The skills critical thinking, cause and consequence reasoning and ability to see conflicts of interests were not frequently used. The students were surprised and unaware of their own and Sweden’s ecological footprints. The most common conflicts of interests were between their lifestyle and environmental impact.

Keywords: Science education, Education for Sustainable Development (ESD), classroom observation, Ecological footprints, upper secondary school

INTRODUCTION
Sustainable development and education for sustainable development are abstract and complex concepts that societies and schools around the world are expected to work with. The World Commission on Environment and Development report Our Common Future (1987) is often referenced to when sustainable development shall be defined. Their definition is “development which meets the needs of the present, without compromising the ability of future generations to meet their own needs”. There are policy documents and reports that discuss the role of education within sustainable development. Learning is seen as an important part in the quest towards sustainability (Scott & Gough, 2003). Education for sustainable development should be based on an integrated approach to environmental, societal and economic development. The individual learner should have the knowledge, values and skills to be an active, democratic and responsible citizen (Baltic 21E). This raises questions about what knowledge and what skills are needed to become an active, democratic and responsible citizen. UN Decade of Education for Sustainable Development 2005-2014 provides the following six characteristics for ESD: Interdisciplinary and holistic learning, value based, critical thinking instead of memorizing, methodological pluralism, participation decision and locally relevant information (UNESCO 2009).

Sweden is unique in that all students have to attend a science course in the upper secondary school irrespective of what programme they choose. The Swedish curriculum
for the upper secondary school (National Agency for Education 2000) states that this subject Science studies is an interdisciplinary subject in which scientific questions can be viewed from different perspectives. The aim is to provide scientific knowledge required to take a stand on issues that are important to the individual and the society, such as sustainable development and energy issues. The subject is about science education for citizenship and future profession.

Our research interest is science education for citizenship in the upper secondary school in Science studies. Science for citizenship is partly about developing people’s ability to promote their opinion in socio-scientific issues. To do this they need knowledge in science and about science – nature of science. Both in science education research and in research about education for sustainable development there are discussions about how students develop knowledge, values and skills to be an active, democratic and responsible citizen. We want to bring these two areas together and study what will be learned when science education takes its starting point in sustainable development.

BACKGROUND
Today there is a consensus that science should be a compulsory school subject but the curriculum is mainly written by scientists who perceive school science as part of further studies in science (Osborne & Dillon, 2008). For a long time science education in school has been characterized by an academic tradition which emphasizes solid ground, the right answers, science structure and science skills (Swedish Research Council, 2005). In literature review of the concept scientific literacy/science literacy, Roberts (2007) describes one vision about science education that is based on situations with a partially scientific content. Socio-scientific issues are scientific related situations that students may face as citizens, in which other considerations than pure science needs to be done. These issues can promote democratic citizenship through science education. Socio-scientific issues are relevant and can bridge school science and students’ lived experiences (Sadler, Barab & Scott, 2007).

The traditional, science-oriented approach to environmental education has been criticized for leading to knowledge about the existence of environmental problems but not leading to action competence. It has not been capable of addressing the social and societal perspectives of these questions (Jensen & Schnack, 1997). Many of the political and moral problems confronting society today are posed by the advance of science and technology. Osborn and Dillon (2008) discuss that these dilemmas require a solution which involves a combination of assessment of risk and uncertainty, a consideration of the economic benefits and values, and some strengths and limits of science. To understand the role of science in such dilemmas students need to be educated to become critical consumers of scientific knowledge.

The Swedish National Agency for Education also finds that the three-dimensional definition of sustainable development by integrating economic, social and environmental factors has not yet been implemented in the Swedish education (SOU 2004:104).

According to the syllabus for Science studies, students shall learn science in contexts of socio-scientific issues such as sustainable development. It seems as though topics with social relevance are more motivating for the students. On the other hand, they are often complex, and therefore more difficult to understand (Aikenhead, 2006). Research has revealed that such issues challenge students’ rational, social and emotional skills. However, several problematic factors are identified, such as that the students can easily be distracted when they are working with multifaceted issues where the outcome is often not clear (Zeidler, Sadler, Simmons & Howes, 2005). This means that there might be a conflict between the dilemma-based issues’ potential for motivating students and for making them focus on the scientific content.
Critical thinking and ability to see complexity are important skills in ESD. Critical thinking is described as reflective and evaluative thinking which necessarily leads to substantiated judgements (Mogensen, 1997). He argues that in the democratic perspective it is important to become a critical thinker. To question critically, and act according to the answers founded, is contributing to the development of a more democratic and sustainable society. Many different areas of knowledge are involved in ESD and the issues are often value based and have an ethical dimension. Such issues often include conflicts of interest between individuals or groups of people (Jensen & Schnack, 1997; Lundegård, 2007). To be able to identify conflicts of interest and to use the cause and consequence thinking can be seen as some criteria for complex reasoning (Ekborg, 2005).

Environmental and development issues are taught in different ways in schools. A study in Sweden identified three different selective traditions within environmental education. These are the fact-based tradition, the normative tradition and the pluralistic tradition (Östman, 2003). In the fact-based tradition, environmental issues are treated as problems that can be solved by more knowledge. In the normative tradition, the aim of the education is to support an environmentally friendly transformation of society. The pluralistic approach is characterized by a striving to promote different perspectives and values when dealing with problems concerning the future world (Öhman, 2008). About half of the teachers in Sweden are teaching in sustainable development in accordance with the normative tradition (Östman, 2003). There have also been critical discussions about education for sustainable development, that it will lead to indoctrination and that the students will not learn skills to think for themselves (Jickling, 1992).

AIM
The aim of this study is to investigate what skills and knowledge students actually use in discussions related to sustainable development. We used the example of Ecological footprints. Our special focus is on the science content.

The research questions are:

What do the students talk about in a discussion about Ecological footprints?
What kind of conflicts of interests do the students bring up in discussions about Ecological footprints?
Do the students use causes and consequences and apply critical thinking in their discussions?

RESEARCH DESIGN AND METHODOLOGY
This is an exploratory study in the sense that the research questions are open and there is a need to learn from the participants in the study (Creswell, 2005). The students were observed when they worked in groups with a task about Ecological footprints. The group discussions were audio recorded and transcribed verbatim. We have followed the Swedish Research Council’s ethical rules (Codex n.d.).

Participants
The study has been performed in an upper secondary school in a town in northern Sweden. The students were in their first year and attended the course Science studies. Before this study started the students had studied ecology and energy and we came in when the content about sustainable development was to be introduced. The 24 students, 4 male and 20 female – attended two programmes: a social science programme and a programme to become hairdressers.
**Education purpose and design**

We followed the class during the first two lessons related to sustainable development. The purpose of the two lessons was to create interest and to make connections between students’ lived lives and sustainable development. It also gave the students the opportunity to see the complexity in these issues and be aware of the global dimensions. The Ecological footprint is a measure of the demand human activity puts on the biosphere. It measures the amount of biologically productive land and water area required to produce all the resources an individual, population, or activity consumes, and to absorb the waste they generate, given prevailing technology and resource management practices (so called global hectares) (Ewing et al., 2008). To understand the concept you need science and it becomes obvious that these issues are global. During the first lesson students, in pairs, calculated their own Ecological footprint. The students used the WWF website (2009) to convert their consumption and waste-production within four categories, food, home, transport and waste into global hectares. During the second lesson the students discussed their results in small groups. There were six groups of four students each.

The design of the small group discussions were that the students were given the opportunity to have an open discussion about thoughts that the footprint calculation lesson created. When the spontaneous discussions ended they were given some questions and claims to discuss, like:

- Globally we use resources corresponding to 1,4 planets, how can that be possible?
- Some countries Ecological footprints per capita.
- Meat- and paper consumption for the richest 20% of the population on earth.

**Data analysis**

The analysis is based on the group discussions from the second lesson. A content analysis was performed (Bergström & Boreus, 2005). The content of the discussions was categorized into different categories. After several readings we found the following categories, the three dimensions of sustainable development—ecological, social and economical dimension. In the social dimension politics, equity issues, health and working conditions were included. We also found the categories environmentally friendly behaviour and personal experiences.

A specific search for utterances which could be interpreted as conflicts of interests, ability to use cause and consequence reasoning and critical thinking was also performed. When students put two interests against each other we have taken that as a conflict of interests. Both if students have shown awareness about the conflicts on a structural level for example between economy and environment and conflicts on an individual level were identified. Within the individual level we included both when students expressed that their lifestyle was threatened and conflicts between different groups of individuals. When students have reflected, evaluated or asked questions about a statement we have taken that as indicators of critical thinking.

**RESULTS**

Overall the discussions are moving from food, transports, energy use and waste-production when the students present their results. The students relate to “environmentally friendly behaviour” which they have ideas about. It was also the most common content of the discussions. When we look at the three different dimensions that often are used when we describe sustainable development; ecological, economical and social dimension we can see that all dimensions are discussed more or less in different groups. Personal experiences were also discussed (table 1).
Table 1. Content of the group discussions. Y means that it was in the discussion three times or more, ¤ twice or less, - means that it was not in the discussions.

<table>
<thead>
<tr>
<th>Group number</th>
<th>Ecology/Science</th>
<th>Economy</th>
<th>Social</th>
<th>Environmentally friendly behaviour</th>
<th>Personal experience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Equity</td>
<td>Politics</td>
<td>Other</td>
</tr>
<tr>
<td>1</td>
<td>Y</td>
<td>Y ¤</td>
<td>Y</td>
<td>Y Y ¤</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>Y Y</td>
<td>Y</td>
<td>Y Y Y</td>
<td>Y ¤</td>
</tr>
<tr>
<td>3</td>
<td>Y</td>
<td>-</td>
<td>Y Y ¤</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>4</td>
<td>Y</td>
<td>Y ¤</td>
<td>Y</td>
<td>- Y Y</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>Y</td>
<td>-</td>
<td>Y Y ¤</td>
<td>-</td>
<td>- Y</td>
</tr>
<tr>
<td>6</td>
<td>Y ¤</td>
<td>-</td>
<td>Y Y ¤</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

In four groups the students were unaware of their own and/or Sweden’s big ecological footprints and were surprised when they found out. The students showed interest in equity issues in five out of six groups (social dimension).

The most common science content that was discussed was about food-chains, foodwebs and population growth. Other comments were about physiology, natural selection and matter flows. The students used science as statements to tell what nature is like, e.g. that nature is trying to keep things in balance. They did not use science or scientific skills as a way to make progress in the discussions or create understanding about science issues. For example when they got information that we use resources corresponding to 1,4 globes, they did not use their knowledge about different natural resources to find out how or if that could be possible.

The most common content in the discussions was “environmentally friendly behaviour”. Below is an example of a discussion about this in one of the groups:

- Sofia: - It would be good if everybody recycle their waste.
- Gun: - Buy ecological stuff.
- Helen: - Stop going by car
- Sofia: - Walk or take the bus

To see the complexity in the discussions, we searched for the above mentioned conflicts of interest (table 2). The most common identified conflicts of interest were between their lifestyle and environmental impact (see excerpt below) and economy and environment. Conflicts of interest between different groups of people and between animals and humans were only mentioned twice each.

- Erika: - ehh, we could live on what we really need
- Tina: - not like this...all the unnecessary stuff and so
- Jens: - how boring life would be
Another way to see complexity is the use of cause and consequence reasoning (table 2). Most common was how economy influences human behaviour and how human population growth will affect the environment. Other examples were about how society creates opportunities for people to live “environmentally friendly”, for example makes it easy to go by bus or create opportunities to sort their garbage. Overall cause and consequence reasoning was not a skill used very often.

In the discussion with Sara, Tina and Anita (group 4) there are examples of critical thinking. This skill was used in three groups but not very often (table 2).

Sara: - but look, if we live at 1, 4 (globes), we still live at one (globe)
Tina: - Yes, everything is still..
Sara: - Who has calculated this, I wonder.
Tina: - Yes
Sara: - We still have enough food
Tina: - Yes, all
Sara: - Don’t we? There is still a lot of food.
Anita: - Maybe Elise’s grandchildren can’t have any food.
Tina: - Yes but what, these poor. They have to get it better. It would be better if it was more equal so that

Everybody starts talking

Sara: - We have to climb down and they have to get up
Tina: - Yes, exactly
Sara: - Yes but what, it is still the same result.
Tina: - Yes but
Sara: - They can’t mean that we all shall live as

Silence
Table 2. Skills used in the group discussions. Y means that it was in the discussion three times or more, □ two times or less, - means that it was not in the discussions.

<table>
<thead>
<tr>
<th>Group number</th>
<th>critical thinking</th>
<th>cause and consequence</th>
<th>conflicts of interests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>lifestyle - environment</td>
<td>economy - environment</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Y □</td>
<td>Y □</td>
<td>Y</td>
</tr>
<tr>
<td>3</td>
<td>Y □</td>
<td>Y □</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Y</td>
<td>Y □</td>
<td>Y □</td>
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<tr>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>6</td>
<td>-</td>
<td>Y □</td>
<td>Y □</td>
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</tbody>
</table>

**DISCUSSION**

The task with calculating their own Ecological footprint and then discussing the results created opportunities for the students to integrate the social, economic and ecological dimension in sustainable development. In the discussions, students focused on environmentally friendly behaviour. When they found out about the equity issues in this task, the interest increased and those issues were discussed. The ecological/science dimension was not discussed much and it was not in a reflective way. The question is whether the students learned any science. At least they never discussed and asked questions about the science content. This study indicates that when sustainable development issues are learned in school, the ethical dimension creates most interest. The conclusion that Aikenhead (2006) discussed that topics with social relevance are motivating for the students but also are complex and therefore more difficult to understand is also indicated in this study. In science education we have a challenge in inquiry based teaching about sustainable development, to create tasks where the students can integrate the different dimensions but also focus on and learn science. The students demonstrated knowledge about environmentally friendly behaviour. The different behaviours were not questioned during the discussions. In the discussions there is a consensus about “a good behaviour”. The results of this study indicate that in this school situation the students thought that they should relate to “environmentally friendly behaviour” and did not use skills as critical thinking, cause and consequence reasoning and identified conflicts of interests that much. If it is the normative teaching tradition in environmental education that causes this is impossible to say. These issues are often discussed in a normative way in school (Östman, 2003) but also in media. It shows that it is important how we construct tasks and that the classroom discourse encourages critical thinking.

According to curriculum and policy documents we shall teach and learn for sustainable development. This study indicates that in these issues we have to plan very carefully so that the teaching encourage critical thinking and not only teach the students norms surrounding it. We also have to give the students opportunities to find out and learn about conflicts of interests on a structural and societal level and not only on the individual level.

**Future direction**

It is interesting how complex issues within sustainable development affect the learning. Do students manage to learn both about the complexity between the different dimensions
and learn science in sustainable development issues? Is the ethical dimension so interesting so that it overshadows the other dimensions or does it enhance learning? How students use and learn skills as critical thinking to make progress in their learning is also important to know more about. This will be studied further.

REFERENCES


