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UNIVERSITY STUDENTS' ARGUMENTATION IN SCIENCE AND ENVIRONMENTAL EDUCATION

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Abstract

In science and environmental education, one of the objectives is to prepare students for participation in the decision making. To be able as an informed citizen to make decisions, it is important to learn to present an argued point of view. The everyday sense of argumentation suggests that participants present claims, defend their claims, and rebut the claims of their opponents. The study focuses on practising university students' argumentation in an authentic situation and also the way students argue. University students familiarized themselves with a proposal to change a provincial plan. After reading the plan, they assumed to the role of a resident of the area in question and wrote to the planners starting their opinion. We had two different cases: the first case was in science education course and the other case in environmental education course. In the second case students wrote to the Wiki-environment and the opponent commented on the argumentation. These writings (N=17) were analysed by content analysis. Although the students used scientific knowledge, especially ecology, in their argumentation, it often consisted of personal feelings about the effect of the plan on their own lives.
Key words: *argumentation, environmental education, science education, higher education*.

Introduction

Argument and argumentative practice is a core activity of scientists; it is also one of the goals in environmental and science education which aims to prepare students for future participation in society. There are many areas of public science-based policy in which the public has a legitimate voice. Many of these issues are complex. Discussion of sosioscientific issues requires a range of skills in order to analyze issues and work toward a decision. In decision making, the skill of being able to present an argued point of view is implicit (Kortland, 1997).

As argument is an important feature in science, research on argument and argumentation in environmental and science education has intensified over the last twenty years. Scientific knowledge is socially constructed, and argumentation is especially needed in pedagogical discursive activities. Driver, Newton, and Osborne (2000) see the centrality of argument in science from three perspectives: the nature of scientific enterprise itself; the role and function of argument within science; the need for science education to promote a better understanding of science and its nature, this enhancing the public understanding of science.

Argument can be considered to be an individual activity, either through thinking and

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writing, or as a social activity within a group, a negotiated social act within a specific community (Driver, Newton and Osborne, 2000). According to Driver et al., in rhetorical mode, argument is used to inform others and persuade them of the strength of the case being presented. The dialogical or multivoiced interpretation of argument is involved, when different perspectives are being examined and the purpose is to reach agreement on acceptable claims or courses of action. The multivoiced nature of argument construction is much more obvious within a group, as individuals take different positions over the claims advanced, and influence, the nature of the argument that can be put together. When student's practice argument in groups, it is an important mechanism for scaffolding students' individual construction of argument (see Driver, Newton and Osborne, 2000.)

The theory of argumentation has been developed since Toulmins' contribution in 1958. It can provide a theoretical basis for developing tools to analyze and improve argumentative discourse. Toulmin's (1958) argument pattern has been used for coding arguments in different contexts. It contains:

- claims, which are assertions about what actually exists and values already held;
- data, which are statements that are used as evidence to support the claim;
- warrants, which are statements that explain the relationship of the data to the claim;
- qualifiers, which are special conditions under which the claim holds true;
- backings, which are underlying assumptions that often remain inexplicit; and
- rebuttals, which are statements that contradict either the data, warrant, backing or qualifier of an argument (see also Simon, Erduran and Osborne, 2006; Sampson and Clark, 2008).

In applying Toulmin's framework, it is difficult to distinguish claims, data, warrants, and backings, because the comments made by students can often be classified into multiple categories (see Sampson and Clark, 2008). Kelly and Takao (2002) state that the scheme in Toulmin's model is restricted to relatively short argument structures and that the argument components pose ambiguities. When the arguments are longer, as is the case when students are writing a paper stating their positions, statements may serve as a new claim or as a warrant for a pre-existing claim (Kelly and Takao, 2002). In the model which Kelly and Takao (2002) used, there are six epistemic levels ranging from most specifically, grounded claims to progressively more general, theoretical claims. In addition to the epistemic levels, the model includes explicit links over the assertions made in the argument. This model allows for the use of multiple claims to support complicated arguments; Kelly and Takao (2002) applied the model to specific cases in a University oceanography course.

Several analytic frameworks have been used in literature to study arguments constructed by students. Regardless of the diverse perspectives, according to Sampson and Clark (2008), these frameworks share several focal issues. Sampson and Clark (2008) see three issues to be of critical importance in the research of the ways students generate argument in the context of science: the structure or complexity of the argument (i.e. the components of an argument); the content of an argument (i.e., the accuracy or adequacy of the various components in the argument when evaluated from a scientific perspective); and the nature of the justification (i.e., how ideas or claims are supported or validated within an argument). For example, the model of Schwarz, Neuman, Gil, and Ilya (2003) is designed for contexts in which students were invited to produce arguments in essays to express their standpoint. In this framework the argument is simply a conclusion with at least one reason. The arguments are quantified by identifying the (a) argument type, (b) soundness of the argument, (c) overall number of reasons, (d) number of reasons supporting counterarguments, and (e) types of reasons included. The hierarchy of argument structure is fairly simple, ranging from a simple assertion to a compound argument. Simple assertions consist of a conclusion that is not supported by any type of justification. One-sided arguments include only a conclusion with one or more reasons. Two-sided arguments

include reasons that both support and challenge the conclusion. Compound arguments include phrases such as, it depends.., if.., but only if... Also the soundness, the acceptability of the argument, and the relevance of the reasons used to support a conclusion, are valued.

Good argument is relative to the context in which it takes place: the validity of an argument is a matter of informal, rather than formal logic, and different areas of human activity will have their own distinctive forms of argumentation (Newton, Driver, Osborne, 1999). Current research indicates that it is difficult for students to learn how to engage in productive scientific argumentation to propose and justify an explanation through argument (Sampson and Clark, 2008). Skoumios and Hatzinika (2009) studied the quality of dialogic argumentation and found that there is a relation between the ground levels and content levels of oral comments of 11-12 year old pupils. Jimenez-Aleixandre and Pereiro-Munõz (2002) found, in the context of environmental management, that 16-17 years old students' decisions were not based solely on conceptual understanding or scientific evidence: value judgements played an important role.

Teaching argumentation is challenging for teachers. Newton, Driver & Osborne (1999) found that opportunities for the social construction of knowledge, afforded by secondary school science through the use of argument-based pedagogical techniques, were few and far between. Simon, Erduran and Osborne (2006) also investigated the teaching of argumentation and found that teachers, whose lessons included the highest quality of argumentation, also encouraged higher-order processes in their teaching.

Here in Finland, Marttunen (1994) studied argumentation skills among Finnish university students and contributes to the measurement of argumentation. The data was derived from written tasks concerning argumentation in the field of sociology education. The analysis was separated into the claims, the grounds and the conclusions. According to the study of Marttunen (1994), students' argumentation skills can be divided into two categories; the analysis of argumentative texts and the skill of composing one's own arguments. Furthermore, results indicated that students' argumentation skills were poor (see also Marttunen & Laurinen, 2009). Also in the context of physics the study of Finnish primary school teacher students' reasoning revealed that students used everyday reasoning based partly on beliefs, and scientific reasoning based on school science (Keinonen, 2007; Keinonen 2008.)

Åhlberg (1998) and his research group has used the ARRA argumentation model, developed from Toulmin's model, because some of Toulmin's original categories and examples were somewhat unclear. ARRA or Analysis of Reasoning Rhetorics and Argumentation contains 9 categories: claims, grounds, warrant, backing, qualifications, rebuttals, real/proper question, rhetorical question and emotional expression (see Åhlberg, 1998.)

The purpose of this study is to clarify the level of arguments used by university students in the context of science and environmental education, especially in the context of participation.

Methodology of Research

Due to the complexity of the problems under study environmental conflicts offer good opportunities for evaluating options. University students were asked to assess and comment on an authentic provincial plan under development. The students could assume the position of somebody living in the planning area, whose life may be influenced by the plan. Real-life issues as a teaching strategy, involves conflicts between contradictory interests and cannot be resolved with straightforward affirmative or negative answers. Authentic problems do not need to be 'genuine', but the issue chosen should be authentic as it adds motivation and interest for the students, offering them the possibility of discussing it in the classroom and to some extent trying to influence, the real world outside the classroom (Jiménez-Aleixandre and Pereiro-Munõz, 2002).

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The provincial plan affected the area near the university. Two case studies were carried out with different teaching strategies, but studying participation the same authentic issue was used. Firstly, in 2007-2008, primary school teacher students (N=8) in Science and Technology education wrote their comments on the plan as a piece of homework, having familiarized to themselves with the plan and the corresponding map. The students first presented their comments to their peers in one of the 45 minutes lessons and these comments were then the subject of discussion.

In the second case, university students (N=9) participating in the course: Basics of environmental education in 2009, wrote their comments on the same plan. The course consisted of working in groups and lectures aimed at introducing the theory of environmental education with its practical examples and general models. In accordance with most of environmental education, the goal of working in small groups was to promote students' skills in four dimensions: sensitivity, knowledge, action, and participation. Sensitivity should be aroused in the early stages of education, to be later developed towards skills for participation in society as a globally responsible citizen.

The Wiki-e-learning environment was used in this latter case. Students wrote the first version of their comments, and their answered as opponents in the Wiki environment. Taking opponents' comments into account, the students modified or corrected his/her first comments. In other words, they could choose the topic and write a standpoint on it. Students could also see the maps in question on the internet page of the Regional Council of North Karelia. As an outcome, students documented and wrote descriptions. The length of these descriptions varied from half to one A4 page.

Seventeen writings were analysed in the framework of the argumentation theory. It was found that in addition to the modification of Toulmin' s model, the model of Schwarz, Neuman, Gil, and Ilya (2003) was also applicable. The arguments could also be classified according to the nature of both the statements as well as the writings.

Results of Research

Case 1

In case 1, teacher students wrote a one-sided standpoint on the provincial plan from the point a fictional person living somewhere in the planning area. The students chose a living area near a spring and fen (N=1), near a quarry (N=5), or near peat production (N=2). Students' statements were classified as data (D), claims (C), grounds (G), warranties (W), backings (B), and qualifications (Q). Excerpts of the statements are as follows:

D The hill of Kakkarimäki is marked as being in the area where rock is quarried. S7
C Because of this quarrying rock is not economically profitable. S4
G The fen in Niskala is very rich in nutrients. S1
W According to planning regulations, the intake must be reconciled with the area's natural, cultural, and environmental values. S2
B It is an important place for bird-watching, collecting berries and mushrooms, and rambling. S3
Q ... marking the area as a provincial plan is debatable. S3

There were, however, difficulties in classification, as Sampson and Clark (2008) have argued. The statements could be classified in several categories. The frequencies of statements in different categories are shown in Table 1.

Table 1. The nature of students' statements.

Category	Data	Claims	Grounds	Warranties	Backing	Qualifications	Total
Protection of nature, S1	10	11	1	2	1	-	25
Caring about risks, S2	3	6	-	4	1	-	14
Personal beliefs/ caring about landscape							
S3	3	6	2	4	8	1	24
S4	1	9	2	1	3	-	16
S5	2	9	-	1	5	-	17
S6	1	6	-	-	6	-	13
Disagreement through counterarguments, S7	4	4	-	4	-	1	13
Challenging through pondering, S8	4	11	-	1	8	-	24
Total	28	62	5	17	32	2	146

The teacher students mostly made claims, a total of 62, and these were not always related to other statements. When a statement was connected to the claim, it was mainly backing or data. The students made 4 to 11 claims in their comments.

Student 1 used ecological data when he argued, based on the provincial plan or personal (fictional) knowledge of the area. One of the claims was related to human well-being, others to nature. Student 2 had two claims connected to well-being, others were nature-related. Student 2 also highlighted the control of risks. Students 3, 4, 5, and 6 used their own beliefs when arguing, and focused on the landscape issue. Student 7 used counterarguments to the arguments in the provincial plan and student 8 impugned the plan through pondering alternatives.

Student 1, who was concerned with nature presented 11 claims. The argument patter is described in Figure 1.

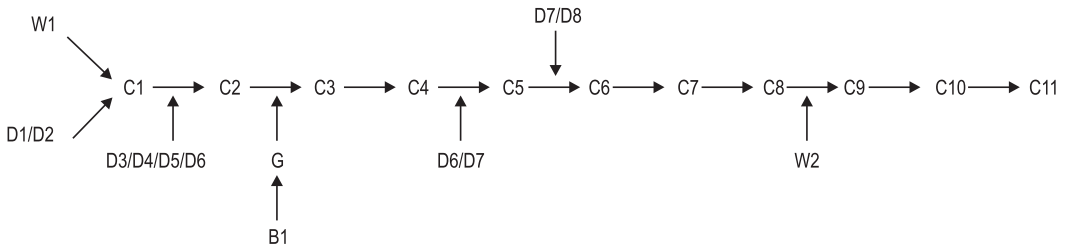

Figure 1. The statement chain presented by Student 1.

The student has used a lot of data from the provincial plan but has also included ecological knowledge and everyday knowledge to reason his claims. His argument on behalf of the spring and the fen in the area explains the use of ecological data but he is also making an appeal for the well-being of the human being.

Figure 2 represents the statement chain of student 7. This was the shortest chain.

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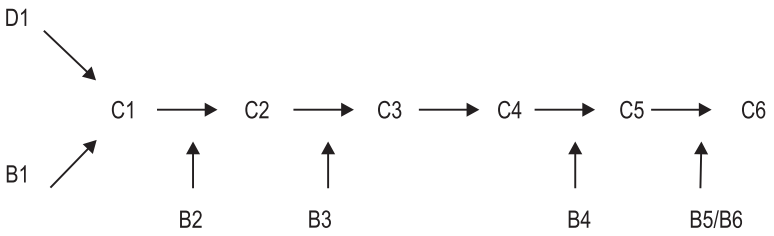

Figure 2. The chain of statements Student 7.

Student 7 mainly used beliefs when he argued in his written comments. He was strongly against the provincial plan, but did not name any authorities, or facts in his statements.

When applying the model of Schwarz, Neuman, Gil, and Ilya (2003), it was evident that there were many arguments which included only an assertion. There were one-sided arguments, somewhat less two-sided arguments, and only a few compound arguments. The classification of the quality of reasons leads to the following findings. The students used abstract reasons, such as hoping that the issue would still be examined, and consequential reasons such as 'damaging effects could be smaller.' However, the students used a lot of sensible reasons including ones that consist of generally accepted beliefs or truths, appealing to the authority (Environmental Institute), or reasons that were based on personal experiences. Vague reasons consisting of imprecise statements were also used in many cases.

Case 2

Phase 1

In case 2 the university students (N=9) wrote comments on the same provincial plan as in the case 1, though it wasn't topical any more. The students, main subjects were peat production (N=3), quarrying areas (N=3), the shooting range area (N=1), the power line (N=1) and the valuable landscape (N=1).

Students' statements were classified into data (D), claims (C), grounds (G), warranties (W), backings (B), and qualifications (Q). Excerpts from the statements are as follows:

D MU-earmark means an area marked for agriculture and forestry in the provincial plan. S11
C The quarrying of the rock incurs damage to the environment which is irretrievable. S12
G The mire is a valuable ecosystem for birds. S13
W According to the Finnish mire scientists….S14
B It is an important place for me for recreation and picking berries S11
Q ...marking the area on the provincial plan is debatable. S16

Table 2 shows the frequencies of statements in different categories which belong to case 2. The students mostly made claims, a total of 80.

Table 2. The nature of students' statements from case 2.

Category	Data	Claims	Grounds	Warranties	Backing	Qualifications	Total
Personal beliefs							
S9	-	5	-	-	-	-	5
S13	1	6				1	8
Caring about risks							
S10	-	9	-	3	2	-	14
S12	2	8		1			11
S17	1	12	3	2	3	1	22
Recrea-tional Need							
S11	3	8		1	1	1	14
S15	2	7			2		11
Economy view, S14	3	14	1	1	2		21
Society view, S16	3	10	3		5	1	22
Total	15	79	7	8	15	4	128

Student 9 had a personal and emotional belief but lacked any knowledge. She wrote that she was thankful for the good hogback area in the North Karelian district. The hogbacks are a very important recreational area for herself and her grandchildren. The agreement pattern is described in Figure 3. This was the shortest and simplest chain.

Figure 3. The statement chain of Student 9.

Student 13 also wrote about emotional beliefs and she was generally worried about the shooting areas in the Joensuu district. She emphasized the noise and used the qualification "every time".

Student 10 presented knowledge which was based on information published in the local and Finnish media. She argued that the peat mining area is too large. She highlighted the risk of drainage for peat extraction. Peat mires are important sites for biodiversity e.g. ecosystems for birds, human heritage and landscape. Many of these values are irreversibly destroyed by drainage and they cannot be restored. The agreement pattern is described in Figure 4.

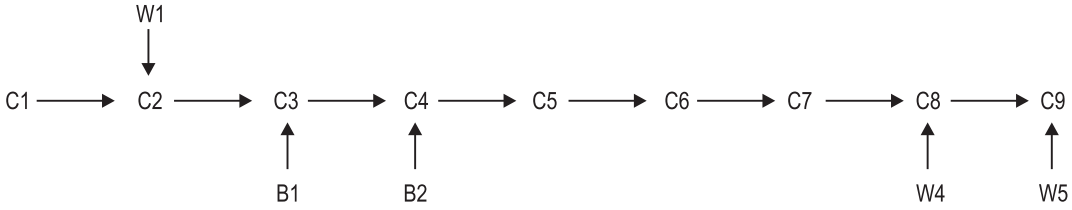

Figure 4. The statement chain of Student 10.

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Student 16 agrees that the peat mining areas on the provincial plan is good, because in the future the use of electricity will be so huge in Finland and local employment is important. He used backing in his e.g. EU renewable energy polices, Finnish scientists and the Finnish Ministry for trade and industry.

Students 11, 12 and 15 wrote about gravel resources. Student 11 recognised the needs of the local customers and society. She highlighted that the environmental aspects have been taken into account in production. Gravel and sand resources need more environmental research and environmental risk management. Student 12 also wrote that the gravel areas are the groundwater resources and she is worried about the risks to the neighbourhood and especially for the local kindergarten. Also the recreational needs are considered important in the writings of both students (12 and 15).

Student 14 wrote that electricity lines are not suitable in his gardening economy. His claims are based on employment and he had personal knowledge about the area. Student 17 used ecological and economic data when she argued. For example she questioned the unclear calculations about the use of electricity in Finland and the forecast of economical growth in the future.

Phase 2

The students first wrote their comments in the Wiki e-learning environment to which their peers reacted with their own comments. After the peer had argued his/her viewpoint, the student revised his/her initial comments. In table 3 we show the nature of the students' statements.

Table 3. The nature of students' statements at the beginning of the task and following their peers' comments.

Data	1st writings	2nd writings	
Category	Number of statements	Number of statements	Total
Personal beliefs	2	0	2
Personal beliefs, real impacts	4	2	6
Society, few aspects	3	3	6
Society, board view	0	4	4
Total	9	9	18

It seems that the peer argumentation practice in the Wiki-environment does provide in some extent the opportunity to develop students' ability to construct an argument. But, if the student had a view which was based on a strong personal belief, it did not change during the reviewing process. The arguments had in some cases changed after the comment phase, taking the whole society more into account, some students' arguments remained unchanged.

Comparing cases 1 and 2, we found that the standpoint written as homework was longer than that written in the Wiki-environment, the argument chains being extended. However, the Wiki-arguments were more precise. Three of the issues which the students chose were the same, but the issues chosen in case two were more varied. This is probably due to the differences in the major subjects of the students.

Discussion and Conclusions

The provincial plan used as a context, interested the students. Authentic problems do not need to be 'genuine', but when the issue chosen is a real problem, it adds motivation and interest for the students, as Jiménez-Aleixandre and Pereiro-Munõz (2002) have reported. In case one, argument can be seen to take place as an individual activity, through thinking and writing; the case two social activity takes place within the groups, a negotiated social act within a specific community of peers (see Driver, Newton and Osborne, 2000). Argumentation is thus not only context specific (Newton, Driver, Osborne, 1999), but it was also found to be teaching strategy specific. When the students wrote their comments alone with the normal text program, their comments were longer than in the case, where the Wiki e-learning environment was used. However, in the latter case, the comments were more precise and based on thinking thoroughly about the subjects. We need to develop a teaching strategy using the good features from both these strategies. Opportunities for the social construction of knowledge should be afforded more (see Newton, Driver & Osborne, 1999).

Argumentation is clearly a skill which needs to be practiced. The university students' argumentation was not precise and did not consist of logical chains of reasoning. Obviously, argumentation should be practiced much more during university studies. However, it was difficult to apply Toulmin's (1958) framework, to distinguish claims, data, warrants, and backings because the comments made by students could often be classified into multiple categories, agreeing Sampson and Clark (2008).

The university students used several pieces of evidence in their reasoning, not only conceptual understanding or scientific evidence but also value judgements which agreed with the findings of Jimenez-Aleixandre and Pereiro-Munõz (2002). The model of Kelly and Takao (2002) with its six epistemic levels, was not found to be applicable; even that the comments should consist of long arguments. In future development work, when the teaching strategy leads to a higher quality level of argument, the model will probably be suitable.

The findings of Simon, Erduran and Osborne (2006), that teachers whose lessons included the highest quality of argumentation also encouraged higher-order processes in their teaching, together with our findings of the level of argumentation, challenges us to use more argumentation in our lessons. Participation in society requires increasing awareness of environmental action. In the future, the environmental problems will be more extensive and more significant because of changes in the environment, thus the role of argumentation in science and environmental education is important. Both environmental education and science education deal with involvement and participation. It is obvious that the university students lacked the opportunity for the practice of argument. Briefly, it is important to develop science and environmental education for university students in order to help students improve their argumentation skills.

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