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'Should We Kill the Grey Squirrels?' A Study Exploring Students' Justifications and Decision-Making

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A problem that is still unexplored in the field of socioscientific issues (SSI) and that was explored in this study is how different students decide upon a SSI they are discussing, how their justifications change during the instruction and how they use (or not) the evidence from the learning environment to support their justifications. For the purposes of this study, two classes (12–13-year-old students) with diverse characteristics were selected from two different schools in the UK. Class A students, considered high achievers come from a white-British background. Class B students considered average achievers come from an Asian British background. The students engaged in discussions regarding a SSI (Should we kill the grey squirrel to save the red?), supported by an online learning environment. Students' written arguments, classroom discussions, and classroom observations were collected and analysed. The findings suggest that even though the two classes engaged with the same learning environment, the decisions and justifications provided by the pairs in the two classes were quite distinct. The students used the evidence from the learning environment in ways which supported their decision, and tended to ignore evidence if these contradicted their decision. Furthermore, students' justifications support the hypothesis that their decision was based on whether they identified with the actors of the issue. Implications for research include exploring how students identify with the actors of a SSI to enable us to support them overcoming their personal narratives and becoming critical evaluators of scientific knowledge.

Keywords: *Socioscientific; Justifications; Decision-making*

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Introduction

Socioscientific issues (SSI) are different from the problems usually presented in science classrooms, since they are ill-structured and involve moral and ethical aspects (Oulton, Dillon, & Grace, 2004). The ability to deal with SSI has been recognized as an important goal of science education (AAAS, 1993; Driver, Leach, Millar, & Scott, 1996; Osborne, 1997; Sadler, 2009). Science poses political and moral dilemmas and engaging with SSIs can enable students to understand the relevance of science to everyday life, gain insight into how people use science, and develop their capacity to be critical consumers of scientific information (Kolsto, 2001). Zeidler, Osborne, Erduran, Simon, and Monk (2003) provide a similar view arguing that SSI should be a part of school science since they can enable students to recognize that there is a human dimension to the practice of science and see the connections of science to everyday life. This argument is supported by Aikenhead's (2006) views of a humanistic science that engages students in more relevant everyday activities, for example, SSI. Furthermore, the inclusion of SSI in science teaching could move science classes towards unwrapping and engaging discussions and, thus promote dialogic arguments, understanding the nature of science, and conceptual understanding. The inclusion of SSI in the curriculum offers a means of expanding both the curriculum and the range of instructional practices commonly experienced in the school science classroom.

Studies in SSI and argumentation so far have focused on students' decision-making (e.g. Jiménez-Aleixandre & Pereiro-Munoz, 2002; Kolsto, 2006; Ratcliffe, 1996), conceptual understanding (e.g. Sadler & Zeidler, 2005; Zohar & Nemet, 2002), and engagement with science (e.g. Albe, 2008). A problem that is still unexplored in our field is how different students (e.g. from different cultural backgrounds, with different experiences, different levels of familiarity with the subject, different levels of achievement in the class) decide about the same SSI, how they justify their decisions, and how they use (or not) the evidence provided. Even though we know that students' cultural experiences and personal narratives influence their decisions (e.g. Levinson, 2008; López-Facal & Jiménez-Aleixandre, 2009; Simonneaux & Simonneaux, 2009), and some studies in argumentation have been conducted across different cultures (i.e. Chin & Osborne, 2010; Kuhn, Wang, & Li, 2011), not much is yet known about how students decide about a SSI they are studying and how different those decisions and justifications might be when comparing diverse populations (e.g. different cultural background, different level of achievement, different experiences). The purpose of this paper is to explore and compare how students from two different classes, and different schools arguing about the same SSI, justify their decisions, how they use (or not) the evidence from the learning environment, and how their justifications change during the instruction.

Such a study is important, especially in today's classes with diverse student populations, since it will enable us to understand how different students think and consequently support them in overcoming their personal narratives and becoming critical evaluators of the scientific knowledge presented to them.

Theoretical Perspectives

Defining SSI

Controversial or SSI are those that significant numbers of people would argue about, without necessarily reaching a conclusion or consent (Oulton et al., 2004). Stradling (1985), for example, defines controversial issues as those issues on which our society is clearly divided and significant groups within society advocate conflicting explanations or solutions based on alternative values. Hence, one can conclude that socioscientific problems are ill-defined and value-laden, invoking aesthetic, ecological, economic, moral, educational, cultural, religious and recreational values that are constrained by missing knowledge (Chiapetta, Koballa, & Collette, 1998). Even though we have used the term controversial issues to help us define SSI, we agree with Zeidler and Sadler (2008) that all SSI are controversial, but not all controversial issues are necessarily socioscientific. Furthermore, according to Zeidler, Sadler, Simmons, and Howes (2005), the socioscientific movement is different from previous efforts in science focusing on the connections of science with everyday life, since SSI:

> focuses specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them. (p. 360)

Hence, socioscientific education is concerned with ethical issues, and involves moral judgment about issues of scientific concern, or SSI represent those social issues and problems that are conceptually influenced by science and require the integration of science concepts and processes (Sadler, Barab, & Scott, 2007). Consequently, when we teach SSI we aim: "to improve knowledge understanding, to contribute to citizenship education, to help students to make informed decisions, to empower them to participate in debates, to help them to be able to deal with complexity, and to understand better the nature of science" (Simonneaux, 2008, p. 181). Zeidler, Sadler, Applebaum, and Callahan (2009) argue that the SSI movement aims to engage students in decision-making about social issues with moral implications, focusing at the same time on character formation. In that way, with the SSI, students are exposed to moral problems with scientific, social and moral viewpoints, which might conflict with the students' personal views, forcing them to focus on the use and interpretation of data and the analysis of conflicting evidence to engage in discussions of viewpoints that might be different from their original ones (Zeidler et al., 2009). Abd-El-Khalick (2003) explains how socio-scientific problems are essentially different types of problems from the ones presented in science classrooms arguing that:

> Engaging in the problem most likely would lead to several alternative "solutions" each with an incomplete set of burdens and benefits. Next, an informed decision (including not making one) is made. However, given the lack of algorithms to go about weighting the identified burdens and benefits, a decision regarding a socio-scientific issue necessarily involves a judgment call… (Abd-El-Khalick, 2003, p.43).

Therefore, an important aspect of SSI as summarized in Abd-El-Khalick's statement is the personal aspect that the students bring in the discussions of the problems, which involves judgment calls from different people. This idea is in line with Zeidler's (1997) notion of intellectual baggage, according to which students "come to our classrooms with prior, well entrenched cognitive and moral beliefs [...] developed over time both formally and informally through a plethora of individual and social experiences." (p. 485). Therefore this intellectual baggage often interacts with how students choose to justify their decision, or on the judgment call they make in an SSI. How different people justify their decisions on the SSI they are discussing, and how they use the evidence provided in the learning environment is part of what our study seeks to explore.

SSI, Scientific Literacy, and Decision-Making

According to a framework for SSI proposed by Zeidler and Keefer (2003), moral reasoning and emotive beliefs are integral elements of reasoning about SSI and are associated with functional scientific literacy—that is scientific literacy that can enable people to function within the society:

> We need to support the development of citizens who are scientifically literate and able to engage effectively with controversial issues. Developing a generic understanding of the nature of controversy and the ability to deal with it is more important than developing students' understanding of a particular issue per se. (p. 415)

Furthermore, SSI are an integral feature of developing what Norris and Philips (2003) term 'derived scientific literacy, that is "being knowledgeable, learned, and educated in science" (pp.224) since consideration of SSI requires students to make informed decisions, deal with ethical and moral issues, develop critical thinking, resolve ambiguity, and deploy scepticism and open-mindedness (Zeidler et al., 2005). Studies in science education have shown: (a) that there is a gain in the learning of content knowledge as a result of engaging in a consideration of SSI (Applebaum, Barker, & Pinzino, 2006; Pedretti, 2003; Zohar & Nemet, 2002); (b) that SSI can serve as an effective context to help students understand the nature of science (Khishfe & Lederman, 2006) since amongst others it is through this process the students understand that some science is tentative, and there is ambiguity even in some scientific knowledge; (c) SSI can help students find links between science and society, and can be used as a way to develop citizenship; and (d) there is evidence that SSI can enthuse students and drive them into discussions around scientific issues (Levinson, 2008).

Research in Socioscientific Contexts, Argumentation, and Decision-Making

Socioscientific contexts have been explored in many research studies, especially in terms of how students engage in argumentation and decision-making within those settings (e.g. Albe, 2009; Evagorou, 2011; Jorde & Mork, 2007; Zeidler & Keefer, 2003). However, most of these studies focus on college or high school students, and less on younger students, which are the focus of this paper. A study by Ratcliffe (1996) with secondary school students explored their ability to evaluate evidence provided in media reports of contemporary science. Students were asked to judge whether a certain claim could be regarded as proven. Some students accepted some information without evaluation, others pointed to insufficient evidence, or to the possible role of the scientists' integrity or beliefs. These results suggest that students are not prepared to evaluate knowledge claims or to support their answers based on evidence. In a similar study, Jiménez-Aleixandre and Pereiro-Munoz (2002) investigated 16–17-year-old students' reasoning and argumentation within the context of a wetland environmental management issue. The authors analysed students' conversations in terms of their decisions and justifications and the skills and knowledge they need to reach a decision. Their results agree with Ratcliffe's (1996) findings, which show that students cannot easily collect and evaluate information, and that values also play an important role in their decisions. Finally, Zeidler (1997) in a paper discussing fallacious reasoning in argumentation put forward the following claims which are associated with decision-making in SSI: (a) students' implicit beliefs interact with the nature of the problem they are studying and they affect their understanding of moral, ethical, or social problems; (b) students do not easily accept evidence that contradicts their initial beliefs; and (c) belief persistence is directly related to strength of initial belief, therefore a stronger initial belief is harder to change.

Kuhn's research in argumentation and informal reasoning is not directly associated with the current study but her work provides insight into difficulties that students have when constructing arguments and justification, and these difficulties are similar to the ones students have in the classroom when they engage in discussions (e.g. Bell, 2004; Sandoval, 2003) or the ones identified in fallacious reasoning (Zeidler, 1997). For example, Kuhn (1991, 1993, 2005) concluded amongst others that: most people tend to be certain of their theories; even people who base their theories on pseudo-evidence believe that what they are saying is indeed genuine evidence; people tend to reason better on the subjects for which they have personal knowledge; people tend to assimilate any new information into existing theories and they express considerable certainty that new evidence supports their theories. These findings from previous studies have been used as guidelines to design the scaffolds within our learning environment that is presented in a later section that would allow the students to construct their decisions and justifications.

The Problem

Many educators use SSI either to encourage their students to develop social consciousness and scientific habits of mind, or as a way to empower them in their decision-making in their everyday life (Simonneaux, 2008). Even though research informs us on how students justify their decisions in SSI, and the array of difficulties educators are facing when teaching socioscientific problems (e.g. Albe, 2009; Jiménez-Aleixandre & Pereiro-Munoz, 2002; Jorde & Mork, 2007; Ratcliffe, 1996; Zeidler & Keefer, 2003) a problem that is still unexplored is how the different students' original views, or the way they identify with the actors of the problem influences their justifications, and how they use (or not) the evidence from the learning environment. Exploring this issue will enable us to understand how different students think, and hence design learning environments that will address diverse needs, and help students overcome their personal views and become critical consumers of scientific information. More specifically, the questions guiding the analysis of the data in this paper are:

(a) What is the type of students' decisions and justifications around a SSI and how do these change during the instruction?
(b) What is the role of the evidence provided in the learning environment on students' justifications?

The SSI and the Learning Environment

The SSI that the students were asked to engage in was whether they agree with the UK government's decision to kill the grey squirrels in order to save the indigenous red (also see Evagorou & Osborne, 2007). Two species of squirrels live in the UK nowadays, the indigenous red, and the grey that was deliberately introduced in the 19th century by the Victorians. Recently the population of the red has declined, whilst the grey squirrel is taking over areas previously inhabited by the reds. There is no direct evidence supporting that the grey is responsible for the decline in the population of the red squirrel but rather that: (a) the grey is carrying a disease that cannot kill grey squirrels but can kill the red; (b) the grey can eat anything, but the red can only eat ripe acorns; (c) the grey can live anywhere but the red can only live in coniferous forests (that also provide their food); (d) the number of the coniferous forests in the UK has been declining since the 19th century due to human factors; and (e) the grey squirrels produce more offspring than the red. Hence the evidence suggests that the grey squirrels have been adapting to the new conditions after being introduced, whilst the red (the indigenous) have not. Despite the aforementioned, in January 2006 the British government announced that grey squirrels are to be trapped, and then shot or poisoned to create buffer zones around areas where red squirrels are living. This decision caused much argument in the media at that point.

In order to engage students with the socioscientific problem, and provide all the evidence to help them construct their arguments either for, or against the government's decision, an online learning environment, Argue-WISE, was designed and used. Argue-WISE is designed within the WISE (Web-based Inquiry Science Environment) platform (Linn, Bell, & Davis, 2004) and makes use of both knowledge representation and discussion based tools. Evagorou and Avraamidou (2008) argue that the design of such a technology-enhanced environment provides scaffolds for argument construction, by making thinking visible, making the structure of argument construction explicit, and by structuring both peer to peer and group discussion.

The theoretical underpinnings guiding the design of the Argue-WISE learning environment are derived from Vygotsky's (1978) sociocultural theory. When using the term sociocultural, according to Lemke (2001), substantial theoretical weight is given to the role of social interaction. This social interaction, based on Vygotsky (1978) and his followers, is central and necessary to learning. More specifically, Vygotsky argues that children acquire their knowledge practices as they interact with others in their community, but their development is viewed as occurring in two planes: the interpersonal (within social groups) and the intrapersonal (individual). Hence, cognitive development is relative to the context in which it occurs and 'is actualised by children's participation in the context itself' (Edwards & Westgate, 1994, p. 256). More specifically, the term sociocultural implies that a social group is engaged in a collaborative activity that is mediated by tools, people, symbols, language and action (Ash, 2003) and usually, in modern societies, the main negotiating medium in this process of learning and teaching is language. The Argue-WISE learning environment is designed in such a way as to promote discourse and help students participate in small communities of learners in which they interact with their peers, the computer and the teacher in order to share their knowledge and mediate their understanding through the use of language (Evagorou & Osborne, 2007).

The Argue-WISE learning environment builds on previous research relating to WISE, argumentation and SSIs (e.g. Bell, 2004; Clark & Sampson, 2006; Osborne, Erduran, & Simon, 2004; Zohar & Nemet, 2002). Argue-WISE consists of four, 50-min lessons, in which the students have to work in pairs in order to study the problem and find evidence within the learning environment to support their argument. The teachers provided no additional evidence or information. At the beginning of the first lesson the students were asked in pairs, to offer their written opinion in one of the

Figure 1. Screenshot from Argue-WISE

Table 1. Description of Argue-WISE lessons

Lesson	Description of lesson
Lesson 1: What is the problem?	Introduction to WISE and Argue-WISE Introducing the problem Stating their opinion Evidence to help students understand the ecology of the red and the grey squirrel, and to understand how the red and grey squirrels differ Scaffolded with the use of prompt windows
Lesson 2: The red squirrel population: is it dropping?	Investigate the decrease in the red squirrel population and the causes of the change in the numbers of the population Use of SenseMaker, an argument construction tool to scaffold students to collect evidence Study historical data sets informing them about the population of the red squirrel before the introduction of the grey, a map comparing the population in 1940 and 1998, and several internal and external links providing information and reasons for the reduction of the red and the survival of the grey
Lesson 3: How can we save the red squirrel?	Presenting ways to maintain the red squirrel population Information from a BBC website presenting real stories of how people in Scotland acted in order to save the red squirrel, an audio interview with a representative from the UK Forestry Commission, and comments from members of the public about how they are against the grey squirrel as it invades their gardens
Lesson 4: Share your argument	Completing their argument and submitting it within Argue-WISE Presentation of their argument during a whole classroom discussion

Note Windows regarding the problem (*Argument 1*) after reading the introductory page of the learning environment (Figure 1). At the end of the instruction they were asked to offer their final written argument (*Argument 2*). The structure of the Argue-WISE activities as designed by the first author of this paper is presented in Table 1.

The Role of the Teachers

The theoretical framework that informed the design of Argue-WISE was discussed with both teachers (Heather, for Class A and James, for Class B) before the implementation. Even though the learning environment was discussed in detail and both teachers had the chance to familiarize with it, they were not specifically instructed on how to teach argumentation, and none of them had previous experiences in teaching argumentation or using Argue-WISE. Hence, each of the teachers enacted the learning environment based on their understanding of what was discussed with the researcher, and their usual instructional practices, a finding similar to previous studies which shows that teachers enact the same curriculum in very different ways (i.e. McNeill & Pimentel, 2010). The analysis of the whole class discussions (see Evagorou & Dillon, 2011) suggests that Heather and James used different instructional practices during the enactment of the curriculum. More specifically, Heather supported and encouraged discussion in the classroom, her questions were facilitating the dialogue, providing positive feedback to the students, while at the same time helping them to build on each others' ideas and understand the structure of an argument. Additionally, Heather used most of the time for pair discussions and group work, and tried to model argumentation by discussing evidence, and their validity, and how these should support claims.

James spent a considerable percentage of the time explaining the activities and presenting the evidence provided in the learning environment. There was almost no evidence of modelling argumentation, defining argumentation, or explaining the rationale of the activities in his class. Additionally, as it can be understood through James' written reflection, he perceived Argue-WISE as a resource, and not as tool that could support students' decision-making and justifications, and he did not recognize the pedagogy on which the design of the learning environment was based:

> Argue-WISE was accepted as a suitable tool because of an apparently easy to use interface. The project used an already existing resource so content was essentially in place. This left the details of use to be sorted out and of course the pedagogy of exactly how the exercise was to be run with pupils. (James, reflection email)

Table 2 presents the percentage of the teaching time that each of the teachers provided for pair discussions during the implementation of Argue-WISE. The remaining percentage was teacher talk, e.g. reading the text from Argue-WISE (James), giving instructions (James and Heather), asking questions (mostly Heather and to a less extent James).

It is evident from the table that Class A students had much more time than Class B students to work in pairs, and collaboratively write their decisions and justifications. Additionally, as we argue elsewhere (Evagorou, 2009) the analysis of students' quality of arguments suggests that Heather's students improved more in terms of the quality of the structure of their arguments in relation to James' students. More specifically, 7 out of 14 pairs improved their quality of arguments for Class A, compared with 3 out of 13 students for Class B. We are aware that the two teachers in our study applied different instructional practices, and previous studies

Table 2. Instructional time devoted to paired discussions in both classes

	% Class A time	% Class B time
Lesson 1	90	23
Lesson 2	100	60
Lesson 3	100	53
Lesson 4	50	–[a]

[a]Class A lessons were 4 × 50 min, a total of 200 min of instructions, while Class B lessons were 3 × 75 min, a total of 225 min of instruction.

(i.e. McNeill & Krajcik, 2008) suggest that some instructional practices (i.e. making the rationale of scientific explanation explicit for students) resulted in greater student learning of scientific explanations, some instructional practices (i.e. only explaining the components of the explanation, or discussing everyday explanations) had a negative impact on students explanation, while others (i.e. modelling how to construct scientific explanations) did not significantly influence student learning of scientific explanations. Even though the emphasis of this paper is not on teachers' instructional practices, we recognize that Heather's practice (i.e. making the rationale of argumentation explicit and modelling argumentation) might have helped her students improve the quality of their arguments, as opposed to James' practices. However, none of the teachers provided additional information regarding the problem (i.e. information that would justify why the majority of Class A students might choose a specific decision as opposed to a different decision supported by Class B students), and neither presented their own point of view on the issue but only used evidence available through Argue-WISE. Therefore, there is evidence in the enactment of the curriculum supporting differences in the quality of the arguments (i.e. the structure of the argument), but there is no difference in the enactment in the two classes to support differences in the type of the decisions in the two classes.

Methods

This is an exploratory study based on the assumption that "reality is constructed by individuals interacting with their social worlds" (Merriam, 1998, p. 6), and the data were analysed for emerging categories in an iterative manner. This study also has comparative elements since we are comparing how pairs of students from the two different classes developed their decisions and justifications.

The Participants

The participants were the two classes coming from two different schools in the UK. The reason for using multiple case studies (two classes) instead of a single one is supported by Herriott and Firestone's (1983) argument that the evidence from multiple cases is regarded as more compelling and the overall study is more robust. The cases of this study did not aim to use the sampling logic (choosing representative cases from a population), but on the contrary the replication logic according to which multiple cases within a study should predict similar or contradicting results.

Class A: The students were 28, 12–13-year-old students (10 girls and 18 boys) from a private school in the south of England. These students were described by their teachers as high achievers, something that is also supported by the students' Cognitive Ability Test—a test that provides a picture of standard general abilities in language, mathematics, and science. Furthermore, the students come from an area where social and economic conditions are relatively favourable, and the ethnic classification of the pupils is white Anglo-Saxon.

Class B: The students were 29, 12–13-year-old students (10 girls and 19 boys) from a public school in northwest London, described by their teachers as average achievers, something that is also supported by the students' national assessment test scores. Furthermore, these students came from the local community, and the majority is from an Indian-British or Indian background, and three quarters have English as a secondary language.

Data Sources and Data Analysis

Data sources for the purposes of this study included: (a) the written arguments provided by the pairs in the two classes, both before and after the instruction (*Argument 1* and *Argument 2*, respectively); (b) video recordings of all sessions and from two paired discussions from each class; (c) field notes from both classes; and (d) teachers' reflections after the implementation of the learning environment.

The written and oral arguments from the pairs were analysed constructing categories regarding: (a) the justifications and the evidence (for both research questions); (b) the decision and the change in decision (for the second research question); and (c) the socioscientific aspect of the problem (for the first and second research question), as explained in detail in the section that follows.

Justifications. The categories for justification were constructed based on an interaction between the existing argumentation theory, and the answers provided by the pairs. Before explaining how the categories of *justification* used in this paper were constructed, it is important to consider the framework for argumentation on which this study is based (Toulmin, 1958) to help us define the term *justification*. This study draws on Toulmin's framework for argument which sees the essential elements as claims, data, warrants, and backings. According to this framework, data are 'the facts we appeal to as a foundation for the claim' and warrants 'general hypothetical statements, which can act as bridges' (pp. 97–98). Toulmin's Argument Pattern (TAP), presented in Figure 2, shows the connection of data, claims, warrants, backings, rebuttals, and qualifiers, all of which are components of argumentation.

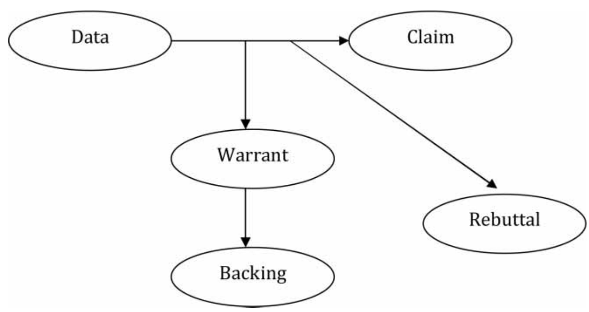

Figure 2. Toulmin's Argument Pattern [TAP] (1958)

According to TAP, data are the facts that those involved in the argument appeal to in support of their claim. A claim is the conclusion whose merits are to be established. Warrants are the reasons that are used to justify the connections between the data and the conclusion, and backings are the basic assumptions that provide the justification for particular warrants. Additionally, in more complex arguments, Toulmin identifies two more features in his framework; the qualifiers that specify the conditions under which the claim is true—and rebuttals—which specify the conditions in which the claim may not be true.

The main criticism of Toulmin's framework is that it is not easy to distinguish between claims, data, warrants, and qualifiers (e.g. Erduran, Osborne, & Simon, 2004; Erduran, 2008; Sampson, & Clark, 2008), because the decision of what counts as data, warrants and claims depends on what was said exactly before that in the dialogue, and to what that refers. Hence, either the researcher has to make an inference (e.g. Erduran, 2008; Jiménez-Aleixandre, Bugallo Rodríguez, & Duschl, 2000; Osborne et al., 2004), or the terms have to be better defined, using indicating words to identify when something is a claim, a warrant, or a rebuttal. Duschl (2008) suggests that this characteristic has an adverse effect on interrater reliability and, therefore, that it should not be used in science education. However, Zohar and Nemet (2002), and Erduran, Simon, and Osborne (2004) in their effort to address this issue and increase the validity and reliability of Toulmin's framework have introduced the concept of *justifications* which are essentially a collapsed category for data, warrant, and backings. The term *justification* as used in this study follows the definition provided by Erduran et al. (2004). Students' justifications were then coded on a basis of their decision about whether to kill the grey squirrel or not, and the kind of justifications they offered for their choice. For example, all the responses from the pairs for *Argument 1* and *Argument 2* were read and analysed based on the Toulmin (1958) framework, and then the justifications were identified and read again in order to create categories (as shown in the tables below). These justifications were compared for the pairs for their first and second arguments, and then the nature of justifications between the two different classes was also compared.

The decision and the change in decision. In this paper, students' outcome or claim is referred to as a decision (e.g. Jiménez-Aleixandre et al., 2000; Ratcliffe, 1996). Students' written arguments from the beginning and end of the lesson were read, and categories of decisions were created (Kill the grey, Intermediate—Do not kill the grey but control the population, Do not kill the grey), with subcategories for each one. Then the decisions of the pairs were compared between the first and second argument to see whether the pairs changed their decision, and whether that change was within the same category or a different category. Furthermore, the type of decisions and how those differ between the two classes were also analysed. Examples from the three categories are presented in Table 3.

The socioscientific aspect of the problem. Other than coding for justifications and change in decision-making, the written arguments from the pairs were also coded

Table 3. Examples from the three claim/decision categories

Claim/Decision category	Quote
Kill	We believe that we should kill the grey squirrels and begin the rise of the red squirrel (Class A, Pair 2, Argument 1)
Intermediate	We believe that the government should make safe havens for the red squirrels. Our evidence for that are that it means we don't have to kill anything except the greys that try to get into the safe havens of the red squirrels (Class B, Pair 12, Argument 1)
Do not kill	We believe that we should not kill the grey squirrels for the red squirrels to live because they are both squirrels at the end of the day, the only difference is they are different species and colour. In addition they are not harming the environment or anyone that lives within the area so we do not see a need in killing any squirrels (Class A, Pair 1, Argument 2)

Table 4. Socio-scientific aspect of students' talk modified from Sadler and Zeidler (2005)

Code	Definition
Rationalistic	This describes reasoned-based calculations. These include applications of deontological and utilitarian principles, cost–benefit analysis, rational assessments and limitations of technology
Emotive-p	Is consistent with the application of moral emotions such as empathy and sympathy. People that use this seem to care about the well-being of others
Emotive-n or personal	People that use this seem to care about their own well-being rather than that of others, or to be driven by feelings of antagonism towards others
Intuitive	Considerations based on immediate reactions to the context of scenario. It is an affective response but it is an unexplainable immediate reaction

in terms of *aspects of the argument*, in order to identify students' argumentation within the specific SSI that they were discussing. The framework used for the analysis of the socio-scientific aspect is a modified version on the one proposed by Sadler and Zeidler (2005), which is based on describing argumentation as an aspect of informal reasoning. Based on the Sadler and Zeidler (2005) framework, the socioscientific arguments can be characterized as *rationalistic*, *emotive*, and *intuitive* (Table 4).

However, with the term *emotive*, Sadler and Zeidler (2005) only account for positive feelings towards others, but our initial analysis showed that some students provide arguments that are based on emotions, that could not be coded as rationalistic or intuitive, and are not positive. For example, Pair 2 from Class A provided the following argument:

> We believe that the government should electrocute them all [grey squirrels] with metal serving trays connected up to the mains. Our evidence for that is they are annoying, can eat food before the reds and give them squirrel pox [...]. (Pair 2, Class A)

Based on our initial analysis it was decided that an additional category was also necessary to account for our data, hence the *emotive* category from the Sadler and

Zeidler (2005) framework was renamed the *emotive positive* (*emotive-p*), and a second category added which was labelled as *emotive negative* (*emotive-n*) *or personal* which was defined as: "Is consistent with the application of moral emotions. People that use this seem to care about their own well being rather than that of others, or to be driven by feelings of antagonism towards others".

The first two authors coded together one-third of the written justifications, the decision and change in decision and the SSI aspect of students' arguments to develop and refine the coding schemes. The remaining written arguments were analysed independently by the first two authors and the percentage agreement was 90% for the written justifications, 98% for the decision and change in decision, and 86% for the SSI aspect of students' arguments. All disagreements were resolved through discussion. The video recordings of whole classroom discussion from all sessions from each class were transcribed, and those critical episodes in which students were talking about their justifications and decision-making were analysed by the first author based on the categories of analysis explained above. Then 20% of the critical episodes were independently coded by the third author with 70% agreement. All disagreements were resolved through discussion. The field notes from both classes were used to assist with the analysis of the videos and students' attainment levels were used as a way to identify differences in performance between Class A and Class B.

Results

Table 5 presents the total number of the different decisions that were provided by the students in both classes for the initial and final argument (Arg.1 and Arg.2,

Table 5. Total number of different claims (Arg. 1 and Arg. 2) for the two classes

Claim/Decision			Class A Arg. 1 $N = 14$	Class A Arg. 2 $N = 11$	Class B Arg. 1 $N = 14$	Class B Arg. 2 $N = 12$
Kill the grey	All	All	3	2	2	1
		All male	1			
	Some	Majority	1			
		Part	1	4		2
Intermediate (do not kill but control)	Control the population		2			
	Move greys	Unidentified location	2	2		
		Back to their country	1	3		
Do not kill	Actions to improve status of red		2			
	Do not kill because is in human		2	12	9	

respectively). *N* in the table does not always correspond to the number of the pairs (14 pairs in each class), but to the number of claims provided. For example, for the second argument, Pair 11 in Class B provided two claims. Additionally, for *Argument 2* for both Class A and B, three of the pairs either did not provide a response or were absent that day, so an argument was not available.

The decisions provided by the pairs were divided into three categories, the two claims that were already provided by the learning environment (Kill the grey and Do not kill the grey), and a third claim, that we have labelled as *Intermediate*, Do not kill the grey but control. This category is essentially different from the one labelled as 'Do not kill' since students that provide this claim recognize that a solution different from the one provided by the government is also possible (see Table 3 for examples).

As shown in the Table 5, for *Argument 1* six of the claims provided by Class A pairs belong to the category *Kill the grey*, five in the intermediate category and the rest in the *Do not kill* category, which is quite different from what is happening in Class B. For Class B for the first argument most of the students (12 pairs) stated that we should not kill the grey squirrel because that is inhumane and the rest that we should kill all the grey. What is interesting here is that for Class A there are a lot of intermediate decisions, but none of the pairs in Class B provide any intermediate decisions for the first argument. The situation is similar for the second argument as well, with the majority of the pairs from Class A (six pairs) providing an intermediate decision, and most of the pairs in Class B (nine pairs) insisting on the original claim that we should not kill the grey squirrel.

Hence the data in Table 5 suggest that the pattern of decisions is similar before and after the instruction for each one of the classes, but Class A and Class B, two different

Table 6. Change in claim/decision for pairs from Class A

Level of change	Category of decision	Subcategory of decision	Pairs
Change $N = 7$	Inside *Kill the grey*	Kill All ⇒ Kill Some	Pairs 4 and 10
	Inside *Intermediate*	Control Population ⇒ Move Greys	Pair 1
	From *Intermediate* to *Do not kill*	Improve Red ⇒ Control Population.	Pair 6
	From *Intermediate* to *Kill*	Control Population ⇒ Kill Some	Pair 11
	From *Do not kill* to *Intermediate*	Do not Kill ⇒ Control Population	Pair 12
	From *Do not kill* to *Intermediate*	Do not Kill ⇒ Move Grey	Pair 13
No change $N = 4$	Kill the grey	Kill All ⇒ Kill All	Pairs 2 and 5
	Kill the grey	Kill Some ⇒ Kill Some	Pair 9
	Intermediate	Move Grey ⇒ Move Grey	Pair 7
No final response $N = 3$	Kill the grey	Kill Some ⇒ No response	Pair 8
	Intermediate	Control Population ⇒ No response	Pairs 3 and 14

Table 7. Change in claim/decision for pairs from Class B

Level of change	Category of decision	Subcategory of decision	
Change $N = 2$	Inside *Kill the grey* and *Do not kill*	Kill All ⇒ Kill Some + Do not Kill	Pair 11
	From *Do not kill* to *Kill*	Do not Kill ⇒ Kill Some	Pair 13
No change $N = 9$	Do not kill	Do not Kill ⇒ Do not Kill	Pairs 1, 5, 6, 7, 8, 10, 12, 14
	Kill the grey	Kill All ⇒ Kill All	Pair 9
No response	Do not kill	Do not Kill ⇒ --	Pairs 2, 3, 4

classes in terms of students' characteristics, have very different patterns of decisions even though they are using the same learning environment. Tables 6 and 7 present the changes in the claims of the pairs from the two classes, showing in that way which pairs changed their decision and if that change was within the same category or a different category.

Table 6 shows how each one of the pairs in Class A changes their initial decision after the implementation of the learning environment. The main conclusion here is that half of the pairs (seven pairs) changed their initial decision/claim after the implementation, three pairs changed their decision within the same category, and four moved to a different category. An important observation here is that all those pairs that decided that we should kill the grey squirrel in their first argument, either did not change their decisions or changed within the same main category.

Table 8. Justifications of pairs for both classes, for both arguments

Justifications		Class A		Class B	
		Arg. 1	Arg. 2	Arg. 1	Arg. 2
For the red squirrel	To help the population of the red	4	0	1	1
For the grey squirrel	The grey is not responsible	0	0	1	1
For both red and grey	[Do not kill them] to be fair to both species	1	0	0	0
	It is inhuman/racist/illegal	4	1	10	5
	Separating them is the only solution instead of killing	0	2	0	0
Against the grey squirrel	The grey is responsible for the decline of the red	1	4	0	3
	The grey are pests/people don't like them	0	2	1	0
	The grey are not native	0	2	0	0
No justification/does not make sense		4	3	1	4

[a]Some pairs provided more than one justifications.

Table 7 presents the changes in the claims from *Argument 1* to *Argument 2* of the pairs from Class B.

The main conclusion from the data in Table 7 above is that most of the pairs in Class B did not change their decision (not to kill the grey), which is very different from the decisions and change in decisions provided from the pairs in Class A. However, in order to understand why the decisions are different for the two classes we have to look into the justifications provided by each group. Table 8 presents the justifications that students from both Class A and Class B used to support their claims/decisions both for the first and the second argument.

As shown in Table 8, Class A students provide a wider range of justifications than Class B students. Additionally, Class B students focus on the inhuman/racist/illegal part of the issue, but Class A students (especially for Argument 2) use the evidence to change their justification. So most of the pairs in Class A provide justifications that belong to the category *the grey is responsible* and they use evidence from Argue-WISE to justify their claim, while most of the pairs in Class B (five pairs) insist that it is inhuman to kill the grey squirrel, even though some of them recognize that the grey is responsible for the decline of the population of the red. Comparing Table 8 with the data in Table 5 (the decision and change in decision) we see that even though Class B students identified that it is inhuman to kill the grey, and the grey is responsible, none of the pairs provided an intermediate claim (Do not Kill but control the population).

Table 9 presents the change in justifications for the first and second argument for Class A students.

Most of the pairs in Class A change their justification for *Argument 2*, and these are justifications for a more negative judgment of the grey squirrel. More specifically, most of the pairs state that the grey squirrel is responsible or a pest or that it is not native. These justifications are based on evidence provided within the learning environment, which show that the grey squirrel was introduced in the UK in the

Table 9. Justifications for Arguments 1 and 2 for Class A

Level of change	Pair	Justification 1	Justification 2
Change $N = 10$	Pair 10	No justification	⇒ The grey is responsible
	Pair 11	Inhuman	⇒ The grey is responsible
	Pair 14	Help the population of the red	⇒ The grey is responsible
	Pair 1	Inhuman	⇒ The grey are pests
	Pair 2	Help population of red	⇒ The grey are pests
	Pair 5	To be fair on both	⇒ The grey are not native
	Pair 13	Inhuman	⇒ The grey are not native
	Pair 7	It is inhuman	⇒ Separate is the only solution
	Pair 12	To help the population of red	⇒ Separate is the only solution
	Pair 6	No justification	⇒ Inhuman
No change $N = 1$	Pair 9	The grey is responsible	⇒ The grey is responsible
No response $N = 3$	Pair 3, 4, 8	No justification	No response

nineteenth century, and the population of the grey is increasing. Furthermore, in one of the web pages within Argue-WISE there was an interview with a villager saying that the grey squirrels are annoying, which might be why some of the pairs say that the grey squirrels are pests. An example of a group that changed their justifications from *Argument 1* to *Argument 2* is that of Pair 1 in Class A, and their justifications are:

> We should not kill the grey squirrels but send them off to different places so the red squirrels can live there, if the greys start taking over then capture them and put them back where they came from because they have a right to live. We believe that the government should abduct all grey squirrels and put them in America. Our evidence for that are people [believe that] the reds are magnificent creatures and greys are killing them, and the red squirrel is one of Britain's best-loved mammals. (Class A, Argument 2, Pair 1)

Table 10 presents the change in justifications for the first and second argument for Class B students.

As shown in Table 10, the change in justifications is very different for Class B pairs since most of the pairs who justified their original decision based on the assumption that it is inhuman to kill the grey do not change their justification after the instruction. This suggests that the students persist on their original decision, and even though they have evidence stating that the grey is an introduced species and is taking over the food from the red, they have not used these pieces of evidence in their arguments but rather based their justifications on emotive reasons (e.g. it is inhuman). An example of how a pair shifts from one type of justification (inhuman) to another (not the greys' fault) is that of Pair 12, Class B. This argument is an example of how the students used the evidence provided within the learning environment in line with their original decision:

> We believe that we should not kill any of the grey squirrels. It's very cruel to kill the grey ones just to protect the red ones. (Pair 12, Class B, Argument 1)

> We believe that the government should not the kill the grey squirrel in order to save the red one because grey ones have loads of ways of surviving and they can adapt to their

Table 10. Justifications for Arguments 1 and 2 for Class B

Level of change	Pair	Justification 1	Justification 2
Change $N = 8$	Pair 1	The grey is responsible	⇒ Inhuman
	Pair 11	Help the population of the red	⇒ Inhuman
	Pair 12	Inhuman	⇒ It is not the greys' fault
	Pair 8	Inhuman	⇒ We cannot save the red anyway
	Pair 5	Inhuman	⇒ Help the population of the red
	Pair 9	The grey are pests	⇒ Grey is responsible
	Pair 14	No justification	⇒ Grey is responsible
	Pair 10	Inhuman	⇒ No justification
No change $N = 3$	Pairs 6, 7, 13	Inhuman	⇒ Inhuman
No response	Pairs 2, 3, 4	Inhuman	

Table 11. Socioscientific aspect of pairs' decisions for Class A and B

SSI aspect of decision	Class A Arg. 1	Class A Arg. 2	Class B Arg. 1	Class B Arg. 2
Emotive-p	7	2	8	5
Emotive-n or personal	0	4	1	0
Intuitive	1	2	1	0
Rationalistic	2	3	1	5
No category	4	4	3	4

> habitat. You can't blame the grey ones for the deaths of the red ones. The red ones don't die just because of the grey ones. Most of them die from bad disease [...]. Our evidence for that is, the greys have originated from woodlands of North America and are able to digest acorns when they are unripe which is a good thing. So in broadleaf woodlands the grey squirrels eat the acorn before the reds can. Sadly this reduction in acorn in the red squirrel's diet causes weight loss, reducing their chances of surviving the winter and breeding successfully. However, the grey squirrel has extra body weight that means that they can store three to four times more fat than the red so they have a better chance surviving the winter. The grey squirrels also produce more young than reds. (Pair 12, Class B, Argument 2)

The justifications provided by the pairs in each one of the classes were also coded in terms of their socioscientific aspect (emotive, intuitive, rationalistic, personal) as presented in Table 11.

The analysis presented in Table 11 shows that there is a great change in the socioscientific aspect of the decision between the two arguments for Class A and Class B. More specifically, Class A students provided mostly emotive arguments (e.g. empathy and sympathy towards the grey) for *Argument 1*, but after exploring the evidence provided within the learning environment (e.g. red is indigenous) they changed their decision and their justifications to support the red squirrel (e.g. emotive-n). On the contrary, Class B students provided mostly emotive arguments at the beginning of the instruction, but then a considerable percentage provided rationalistic arguments which accounted the different reasons for which the population of the red was declining.

Discussion

In contrast to previous movements (e.g. Science Technology Society), SSI examine students' personal philosophies and belief systems (Zeidler et al., 2009) and try to understand how these can affect students' decision-making. Work in the field of SSI (i.e. Jiménez-Aleixandre et al., 2000; Zeidler, 1997) and in the field of everyday argumentation (i.e. Kuhn, 1991) has shown that students tend to decide based on their personal beliefs and experience even if their decisions contradict the available evidence. However, what previous studies in the area of decision-making, argumentation and SSI have yet to explore, and what our study is addressing, is how students with different characteristics, engaging with the same SSI learning environment justify their decisions, and compare how different students use the evidence from the same learning environment. Summarizing our findings, the analysis from the two classes has shown that the students (students from different cultural backgrounds, different achievement levels, taught by different teachers) approached the same SSI, introduced from within the same learning environment, in very different ways. More specifically: (a) Class A and Class B students provided completely different decisions and justifications especially after the instruction, with more students in Class A choosing to kill the grey squirrel because *it is responsible for the decline of the population of the red, or a pest* and more students in Class B deciding to protect both the red and the grey because *it is inhuman or racist to kill an animal*; (b) the students in the two classes used the evidence in accordance to their decision and chose to ignore evidence that contradicted their view of the problem; and (c) the socioscientific aspect of the decision was similar for both classes for the first argument but differ for the last argument with more students in Class B providing rationalistic arguments (Table 11).

Students Decide Differently and Provide Different Justifications on the Same SSI Even After Instruction

The same SSI problem was presented to the two classes in our study, and pairs in both classes were asked to provide their opinion on the issue before even any information as to the two different populations of the squirrels was provided. Consequently, the students were not aware that the grey squirrel was the introduced species and the red the indigenous, and most of them had never seen a red squirrel, even though they could see grey squirrels everyday either in their house yards or in the school yard. The students in Class A, a class with students from the same white British (white Anglo-Saxon) cultural background, and considered as high achievers, when first presented with the problem they either supported that both species should be preserved or that the red should be preserved, and only one pair supported that the grey should be killed in order for the red to be saved. Later, when they studied the evidence within the learning environment (e.g. red is indigenous, the grey eats the food before the red, the forests that are habitats for the red are destroyed by humans) they provided decisions and justifications that were against the grey (i.e. the grey is a pest). On the contrary, most of the students in Class B, students with an Indian-British cultural background and considered as average achievers, for their first argument provided decisions and justification that supported both the red and the grey (i.e. it is inhuman to kill any of the two). Their justifications for the second argument were quite similar to their initial ones, with only some pairs (3/13) providing justifications against the grey squirrel (Table 8). Comparing the justifications in the two classes before the instruction (*Argument 1*) and at the end of the instruction (*Argument 2*) it is evident that the initial arguments provided by the pairs in both classes are quite similar in that they decide based on the fact that the red squirrel should be saved, but without arguing against the grey. On the contrary, at the end of the instruction most of the pairs in Class A provided decisions against the grey squirrel as opposed to half the pairs in Class B that insisted on their initial justification that it is inhuman or racist to kill the red.

What is worth exploring is why these two classes provide different types of justifications and decisions even though they are engaged with the same learning environment, and consequently explored the same data sets. An obvious reason would be the teachers and their role in the whole process. As we argue in a previous section, the role of the teacher in the enactment of this learning environment is important, and we are aware that the two teachers used completely different instructional approaches, but did not use any additional evidence and did not provide their personal beliefs or opinions. Therefore, we support that the teachers had an impact on the quality of the arguments that the pairs provided (Evagorou, 2009), with Class A students providing higher quality arguments in terms of their structure, but there is no evidence to support that the teaching practices had an impact on the types of justifications and decisions (e.g. if the students suggested killing the grey squirrel or not). Hence we hypothesize that students' intellectual baggage that was 'developed over time both formally and informally through a plethora of individual and social experiences' (Zeidler, 1997, p. 485) had an effect on their justifications and decisions, making them more likely to interpret the information provided to them through the lens of their own experiences, beliefs, and understandings of the world. As the data suggest in our study, the students in Class A had quite similar intellectual baggage's but completely different from the students in Class B. Based on this assumption, the analysis of the data in this study supports the hypothesis that the students use the evidence based on how they perceive the issue, and whether they have a preference for one of the actors of the issue. This is consistent with previous studies in argumentation (e.g. Kuhn, 1991) but also in SSI (López-Facal & Jiménez-Aleixandre, 2009; Simonneaux & Simonneaux, 2009) who examined how students' personal and cultural identities can affect their discussions of an SSI. These researchers concluded that students project their identities, either personal or cultural, onto the actors in the SSI, and in that way making it more difficult for them to reason about an issue without their own belief systems influencing their decisions. For example, in our study the students in Class A identified with the red squirrel (since most of them were against the grey) and the students in Class B identified with both the red and the grey (since they supported the well being of both). Even though we do not have the data that will allow us to argue for more specific reasons that had led to different ways in which the students in Class A and Class B identify with different actors in the problem, we can hypothesize that their different backgrounds (e.g. cultural, different experiences, different levels of achievement), their different cultural experiences and personal identities influence their decisions (Zeidler et al., 2005). Even though the emphasis of this work was not on the analysis of whole classroom discussions, we provide two representative episodes of whole classroom discussion from each one of the classes that show the differences in the justifications of the two classes (emphasis in text added):

Episode from whole classroom discussion in Class A

Teacher A: So what do you believe, we should kill the grey or not and why?

Joshua: We believe that the government should *kill the grey Americans*. Our evidence for that is that *they are not native to Britain* and *they are taking over*. Or the greys could just be exported back to America.

Chloe: It is racist to kill the grey squirrels *even if they are illegal immigrants*.

Gavin: That is like the process of evolution thought. All those you can survive will do so, all those who can't will die out.

Teacher: So are you saying that you shouldn't kill the grey, that's evolution, and just let the nature take its course?

Gavin: Yes.

Teacher: That is a really good point. I really like the way you brought the evolution on.

Adam: I am going to Gavin's point. If it was evolution though, was it meant to be? Because we brought the grey squirrels in, so red squirrels who evolved had no competition really.

Teacher: Excellent. It is really good thinking, well done.

Jim: Adam says it is not natural. *The not natural part is when we brought them here*. Well since they have been here it is natural and as Gavin says we should just leave all squirrels be free. And if there are no more red squirrels left does it matter?

Teacher: Well that is a philosophical question. Does it really matter? Ok. Yes.

Helen: On the other hand *grey squirrels are not part of England's natural nature, they were brought in by humans, yes, but they should not be here*.

Gavin: *We should go out and shoot a few, it doesn't matter*.

John: If we say that grey squirrels are vermin then don't we prefer the reds?

Teacher: Good point. So what is people's justification for calling them vermin?

Stan: This is not about favorites, it should just be about what is happening. So this is not about if we like cats or dogs, if we don't like dogs then we kill the dogs.

Teacher: Thanks, this is a really really good point. Thank you for saying that. It shouldn't be. And do you think this takes a part in public opinion?

Stan: Yes, because *most people would like the red squirrels because they are more likely to get extinct*.

Episode from whole classroom discussion in Class B

Teacher:	Would someone want to say something about this matter of red and grey squirrels?
Students:	*Leave them alone.*
Teacher:	OK, so which one shall we leave alone?
Students:	*All of them.*
Teacher:	OK, leave all the squirrels alone.
Akil:	Sir, I don't understand, why do they want to kill them, *they are just wild animals.*
Janine:	We should not kill the grey squirrels for the red squirrels to live because *there are both squirrels at the end of the day, the only difference is they are different species and colour.* In addition they are not harming the environment or anyone that lives within the area so I do not see a need in killing any squirrels.
Teacher:	Ok, good point.
Saad:	We should not have to harm the grey squirrels to preserve the red. *It is immoral and cruel towards animals*, since they are plenty of other alternatives of preserving the red squirrel species.

It is clear from the episode in Class A that most of these students are identifying with the red squirrel and are against the grey either because the grey is an introduced species and not native to the UK, or because the red squirrel is under extinction and therefore as Stan implies is vulnerable and people tend to favour these categories. On the contrary, the episode from Class B shows that these students do not identify with any of the two actors of the SSI but they consider both the red and the grey as animals with the same rights. Hence the issue is not whether students' decisions are more value-based than knowledge-based, but what kind of knowledge is regarded as relevant by the students (Kolsto, 2006), implying that students' belief systems have an effect on their reasoning.

Students Only Use the Evidence That Supports Their Decision

As argued earlier, the students in the two classes used the evidence that best supported their decision, and ignored the rest of the evidence. This finding is supported by previous studies in scientific argumentation (i.e. Bell, 2004), socio-scientific argumentation (i.e. Ratcliffe, 1996), and everyday reasoning (i.e. Kuhn, 1991). More specifically as Zeidler (1997) states, students do not easily accept evidence that contradicts their initial beliefs, and the persistence of belief is directly related to strength of initial belief, therefore a stronger initial belief is harder to change. In our study it seems that Class B students held stronger initial beliefs, or that their initial beliefs were in line with the evidence provided within the learning environment. This finding has implications on how learning environments addressing SSI issues are designed. For example, for Argue-WISE we choose to embed the SenseMaker tool within our learning environment, a tool that was developed to help students connect all evidence to the appropriate claim (Linn et al., 2004). The findings from our study suggest that the SenseMaker tool did not support students in collecting and using all available evidence to support their justifications, since as we have argued they ignored evidence that contradicted their decision. In view of the fact that we have seen that this technology does not adequately support students exploring an SSI to use all available data, an implication that arises from this study is investigating ways (combination of technologies and instructional practices) that will help students overcome the barriers of their personal beliefs and intellectual baggage and help them consider all available information as part of the construction of an argument. Recent studies in argumentation (i.e. Sampson & Clark, 2008) suggest that such an approach should include ways to challenge students' ideas, and should include having students work together and share their ideas. According to Levinson (2008) when two people talk about an SSI and they disagree, commitment to one's point of view is one of the factors that influence their decision or justification and:

> Commitment introduces the element of belief and the personal and differentiates it from the subjective assertion. The nature of the belief is reflected in its universability and acceptance, distinguishing it from a point of view that can be rational [...] (p. 862)

We suggest challenging each other's point of view in SSI by engaging students in collaborative learning, which when appropriately scaffolded, leads to better learning outcomes (Barron, 2000; Webb & Palincar, 1996) and might help us address the issue of ignoring evidence in argumentation.

Conclusion and Limitations

What our study adds to the literature about argumentation and SSIs is an exploration and comparison about how different students using the same curriculum materials justify their decisions and how they use the evidence from the learning environment. Since this is a case study with multiple variables interacting with each other, the findings can only allow us to theorize (Yin, 2003) that the differences between the students in the two classes (either cultural, differences, different experiences, or differences in achievement) were responsible for the differences in the decisions and justifications. We hypothesize that the most relevant dimension which resulted in this discrepancy in justifications and decisions between the two classes was the differences in the intellectual baggage between the students in the two classes, which caused them to identify with the red squirrel or with both the red and the grey. Culture has an effect on how students perceive science (Aikenhead, 2006), and in a similar way we may say that students' intellectual baggage or their personal narratives have consequences for learning science or for learning to construct arguments. For instance, it may be interpreted that Class A students' understanding of the grey squirrels as a pest or invasive made it more difficult for them to select available evidence and use it in their arguments, or to modify their arguments, allowing for nuances.

A limitation is that the exploratory form of this study does not permit for generalizations in the conclusions. Further studies would be needed to inform our knowledge about how students' backgrounds (cultural differences, experiences, abilities, attainment levels) and their identification influence their decision-making and argumentation. Meanwhile, we suggest that teachers working in classrooms with diverse backgrounds, and curriculum developers working in the field of SSIs need to pay attention to this issue, and design curriculum that takes into account different intellectual baggages and divergent experiences.

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