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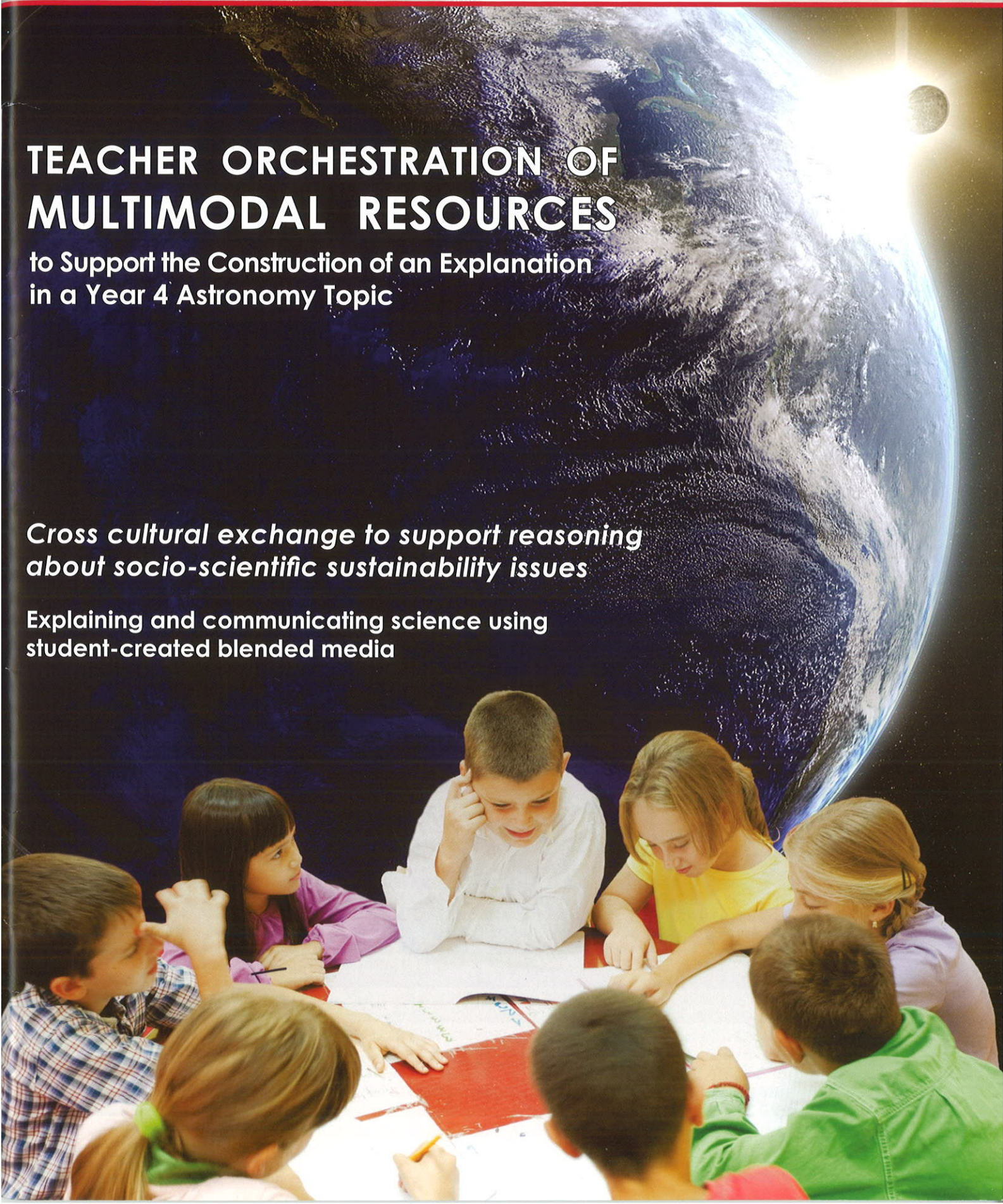


TEACHER ORCHESTRATION OF MULTIMODAL RESOURCES

to Support the Construction of an Explanation in a Year 4 Astronomy Topic

Cross cultural exchange to support reasoning about socio-scientific sustainability issues

Explaining and communicating science using student-created blended media

Cross cultural exchange to support reasoning about socio-scientific sustainability issues

By Olivier Morin, Russell Tytler, Laura Barraza, Laurence Simonneaux and Jean Simonneaux

In this article, we describe a project on reasoning about socio-scientific issues (SSIs), involving French and Australian pre-service science teachers engaged in on-line discussion and development of a wiki. In the research, we developed frameworks for looking at the quality of reasoning about 'socially acute' sustainability questions. We found the level of reasoning was enhanced by the cross-cultural exchange, and identified the importance of context in framing reasoning quality. We argue that science teachers could effectively adapt this approach to develop students' scientific literacy and embed the 'science as a human endeavour' strand of the Australian Curriculum in their practice.

Scientific Literacy and Socio-Scientific Issues

A major aim of science curricula in the 21st century is to develop students' scientific literacy. The focus of school science is thus to prepare students to become adults who are interested in and can engage in science discourse, are able to identify questions and draw evidence based conclusions, are skeptical and questioning, and able to make informed decisions about the environment and socio-scientific issues to do with their lives (Rennie, 2006). The emphasis here is on reasoning and the active use of scientific knowledge to inform action in context. As such, it is aligned with ideas about the promotion of '21st century skills'.

Reasoning about the application of science ideas to relevant contexts such as personal health decisions, or community sustainability issues such as water policy or energy conservation, involves negotiating science knowledge and evidence alongside other forms of knowledge and beliefs such as societal, economic and political knowledge, and values. Thus, considering scientific literacy aims associated with sustainability issues involves developing in students the capacity to reason across these domains (Simonneaux & Simonneaux, 2009a), and challenges technicist notions of sustainability solutions where science and technology are considered the sole sources of knowledge for making appropriate decisions. In fact, the importance of social and ethical aspects of socio-scientific reasoning and decision making is recognized by the scientific community who are inevitably bound up with these debates in research and development (Tytler & Symington, 2006). These human aspects of the operation of science in society are the focus of the 'Science as a human endeavour' strand of the Australian Science Curriculum, which focuses on the way scientific knowledge is created, and how it interacts with society and individuals.

In our research, we are focusing on what we call 'socially acute questions' (SAQs) which are socio-scientific issues that raise questions about important social values and practices, and involve controversy between experts in different disciplinary fields (Legardez & Simonneaux 2006). Reasoning about such issues requires recognition of the relative status of scientific and other forms of knowledge and evidence. Given that these questions can be deeply contextual, and/or can be global in their reach, we are interested to explore the way reasoning is affected by aspects of the context (Simonneaux & Simonneaux, 2009b) and of cultural presumptions and practices that may affect the way the issue is viewed. Do French citizens view water issues, or meat consumption issues, in similar ways to Australian citizens? In the research, French and Australian pre-service teachers of science were involved in an online forum and production of a position on two SAQs, in order to explore these issues. Our research questions were:

1. How might we characterize reasoning about sustainability?
2. How does collectively dealing with a sustainability SAQ facilitate the development of socio-scientific reasoning?

The Method

The intervention took place during the months of March to June 2012, with French students from the University of Lyon in their fourth year of a teacher education degree in biology and Australian students undertaking their third year of a teacher education degree specializing in science and environmental education. Each cohort was divided into four groups, each looking at one of two socio-scientific sustainability issues. These two issues were designed such that one issue was particularly pertinent to Australia, and the second was global in nature. The issues involved:

- The construction of desalination plants to produce fresh water. This issue was particularly pertinent and 'local' for the Australian students since desalination had become a political topic associated with sustained drought.
- The consumption of meat, which was held to be an issue of global scale, and similar in exposure to the French and Australian students.

The sequence of events was as follows:

1. A media file was prepared for each of the two issues, and uploaded onto the project website. Each media file followed a similar structure:

   Each file, consisting of four pages, was designed to provide stimulus information without closing the controversy or claiming to be exhaustive. The intention is to present a diversity of issues and arguments to stimulate additional literature searches. The first page presents the SAQ in a few sentences accompanied by a picture illustrating the questions. This is summarised in a one sentence-oriented choice of individual or collective actions: Meat, Should you eat it or not? Is desalination the solution? This is supplemented by four boxes giving facts such as values - of consumption, of production, of population growth. The second page sets out opposing positions and demonstrates the vitality of social controversy with images of events or parts of slogans. The third and fourth pages are organized on a model of frequently asked questions. They open lines of scientific and sociological thought by providing testimony, results of controversial surveys and research (eg about Melbourne's water supply and drought risk, the financial cost of desalination, potential of technological advances, the dangers of overconsumption of meat, the effects of different types of farms on local agricultural systems and on a global scale) and highlight ethical values involved such as respect for animal welfare.

2. The groups were formed (Salt A and B, Meat A and B for each country) and they discussed the issue and how they would organize themselves to construct the wiki in response to the issue. In the Australian case this was face-to-face. In the French case, for local timetable reasons, it was through an online forum.

3. For each group, an online 'Forum 1' involved discussion separately for the French and Australians, in the group's first language, leading to the construction of a first Wiki by each group, again in their first language.

4. The French wikis were translated into 'rough English' and the wikis of the French and Australian groups were opened to each other to consider. Both groups were recommended to use 'Google translate' and 'word references' to help with understanding the arguments in the wikis.

5. 'Forum 2' was opened for international exchanges in which each partner group questioned the other and attempted to come to a common understanding. This took place in mixed English and French as the French students practiced their English and presented comments both in English and French. Again Google translate was used as a back-up.

6. Reconstruction of the wikis following this international exchange.

7. Individual reflections by the students concerning the process, and their personal positions compared to the group.

Our aim in the analysis of this process, is to follow the quality of reasoning around the issues expressed in the wikis, and to examine the role of the inter-cultural exchange, and the effect of context, on reasoning.

The analysis of the wikis involved the construction and refinement of a socio-scientific reasoning framework with six dimensions, each of which has four positions representing increasing sophistication on that dimension. The dimensions of the framework drew on the socio-scientific literature (Sadler, Barab & Scott 2007; Grace, 2009) and on subsequent research within the Toulouse team (Saoudi & Simonneaux, 2007; Simonneaux & Simonneaux, 2009a; Morin & Simonneaux, 2010). These dimensions are shown in Figure 1. The framework was refined and extended in the current study. This analysis was an iterative process involving multiple discussions and comparison within the research team, checking until a degree of agreed coherence was reached. The refinements involved improving the clarity of the descriptors along each dimension and ensuring they represented a coherent progression, and ensuring that each level across the six dimensions represented a coherent position on knowledge production and application. The framework, with levels, is shown in Table 1.

We will illustrate the application of the framework to judgments about the quality of reasoning represented by the wikis. The quote below, from the first wiki of the Australian Salt A group, is judged as level 2 on the 'Problematization' dimension (P2) since it considers the issue from different points of view, but about the environmental aspect only.

> *One of the main controversies surrounding desalination plants is the potential damage to the surrounding environment. In the case of the Wonthaggi plant, there have been numerous protests and negative opinions about the environmental impacts the building, and running of the plant will result in.*

Later in the wiki however, further aspects of the desalination issue, relating to economics and public costs, were raised. The level of reasoning in the wiki on this dimension was thus judged to be P3.

> *The construction of the Wonthaggi desalination plant will provide the community with both positive and negative long-term economic implications. The total cost of creating the desalination plant [...] has blown out to $4.8 billion in tax payers' money. Additionally Drill suggests that Victorian taxpayers can expect to pay around 24 billion dollars over a period of 28 years in water bills to cover the cost of running the plant*

The following excerpt, from the final Australian Meat B wiki, is evidence of a high level of reasoning on:

1. uncertainty and risk (U4) since it speaks of the balancing of different forms of knowledge applied to this particular context;

2. interactions (I3) since it looks at the likely effects of policy over time, and across different populations (farmers, consumers and sustainability); and

3. regulation (R3) since it envisages the active participation of stakeholders in an open regulatory process.

> *Higher beef and other meat prices for that matter would not only result in better sustainability but also a reduced need for support payments to farmers. In saying this, this could result in a greater difference between the health and ability of the rich to survive ahead of the poor. [...] it begs the question as to where the line can be drawn between free will being too controlling. For that reason, perhaps the best solution is education for all consumers. [...] could result in the public making wiser decisions about their purchases and eating of meat in excessive amounts.*

Through this dual process of analysis of reasoning in each wiki, and refinement of the framework, each of the sixteen wikis (wikis 1 and 2 of each of the four French, and four Australian groups) was given a score on each of the six dimensions. The key questions related to whether there were differences in reasoning on the two issues related to either local contextual factors, or cultural factors, and whether there was an improvement in reasoning following the cross-cultural exchanges. Having been exposed to different perspectives on these issues, were the students challenged to improve their reasoning?

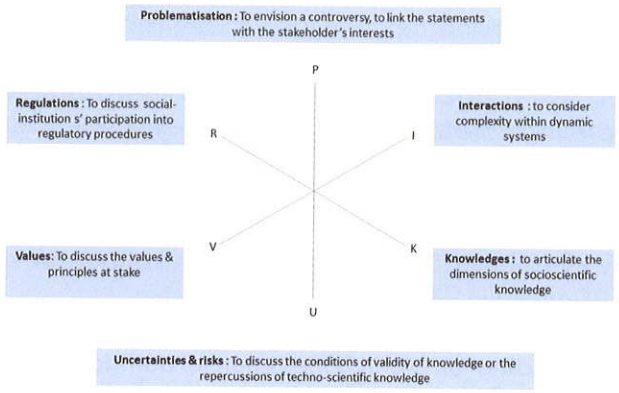


Figure 1: A Socio-Scientific Sustainability Reasoning (S^3R) analysis model (after Simonneaux, L., in press).

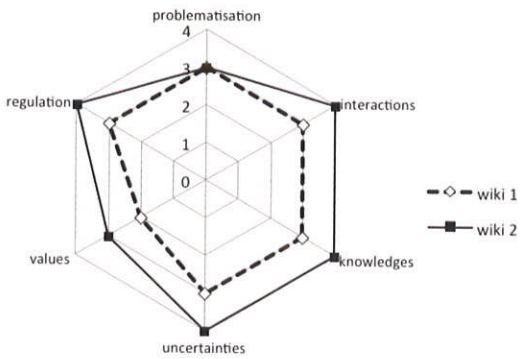
FINDINGS

Figure 2 shows the results for reasoning levels on each of the six dimensions, for wikis 1 and 2, for the Australian and French Meat A groups and the Salt B groups, each of which engaged in joint discussion.

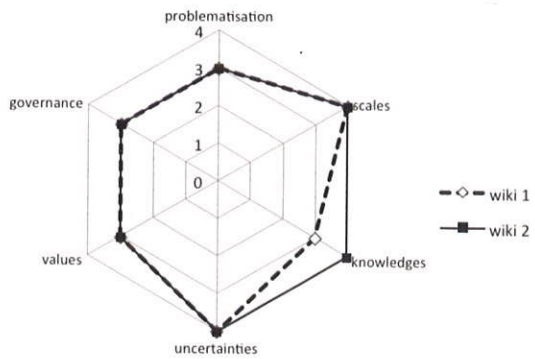
There are a number of interesting features to these diagrams that point to contextual features of reasoning, and also growth in reasoning related to the exchanges. The growth in reasoning from wiki 1 to wiki 2 was substantial in the case of meat, more so for the French team, and least substantial for the Australian salt group who were already reasoning at a high level in the first wiki.

The first wiki of the French team about meat consumption is mainly a list of foods that can provide alternative protein intake necessary for good health. Students gave priority to the scientific approach by focusing on dietary aspects. This wiki evolved with the Franco-Australian exchanges in the direction of greater consideration of human aspects: the arguments are still based on scientific and universal-value knowledges but also incorporate features of the local situation. For example the socio-economic implications of the transition to organic farming and the cultural dimension of the act of eating.

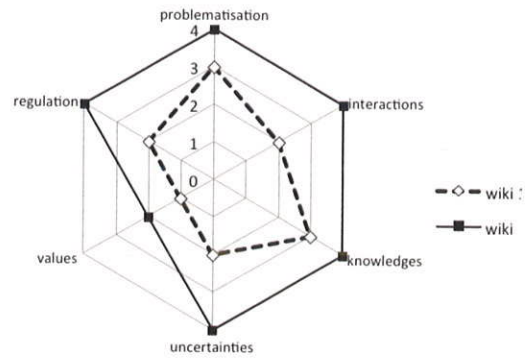
In the first Australian wiki, several aspects of the SAQ are considered. It also presents an alternative search of food but this list does not constitute the bulk of the wiki. This first draft is primarily oriented towards possible changes in agricultural practices and the economic system of meat distribution. The second Australian wiki shows a deepening of the reflections following discussions with the French: thus, the health risks of overconsumption of meat are cited, the list of alternative foods is no longer limited to other meats, but is extended to foods of plant origin, the environmental impact is not limited to pollution but also considers the depletion of resources (for example water consumption related to meat production is taken into account), and a discussion of



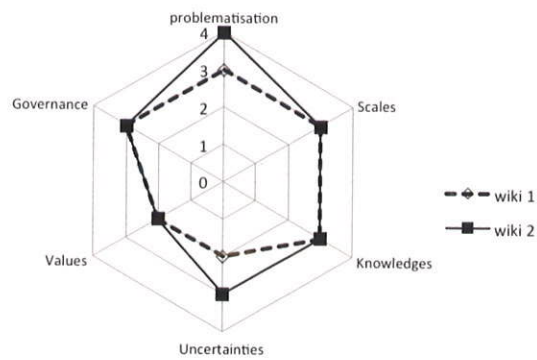
Meat A Australian



Salt B Australian



Meat A French



Salt B French

Figure 2: Growth of reasoning from Wikis 1 to 2, for the French and Australian Meat A and Salt B groups.

		Level 1: There is one right answer. The task is to identify the right form of knowledge.	Level 2: Recognition of multiple positions, values, knowledges without seeing need for integration. Juxtaposes, lists, describes.	Level 3: Identification of many elements and recognition of a need for integration of knowledges, aspects, values, and participation of different stakeholders. Coherence, however, is built around one aspect only.	Level 4: Knowledge is complex, plural, contingent, uncertain and conditional on context. Multiple positions can be justified depending on values. Interests need to be managed in a democratic negotiate process. Socio-eco systems are dynamic and interactive.
The graduation deals with the awareness of complexity in the construction of the problem	**P: Problematisation** Are the disparate aspects (environmental, social, economical) of the situation tackled from different perspectives?	*Tackles the issue and its context from only one aspect and one perspective*	*Considers the issue from different perspectives about one aspect, or from only one perspective on different aspects.*	*Considers different aspects of the issue from different perspectives*	*Identifies the nature of controversy around the variety of perspectives, and link this to competing stakeholder interests.*
The graduation deals with the awareness of complexity within dynamic systems	**I: Interactions** Are the dynamics of eco-socio-systems envisaged over different social, temporal or spatial scales?	*Does not consider any distinct scale (social, temporal, spatial) in relation to the issue, which is seen as either very general or limited to familiar, everyday life.*	*Examines aspects (economic, social, environmental) at different scales, beyond generalities or beyond familiar, everyday life contexts.*	*Describes interactions over space and time in the ecosystem, or between different social groups, without considering the interactions between the socio- and eco-systems.*	*Describes interactions across different social, temporal and spatial levels, integrating the eco- socio-systems, relevant to sustainability.*
The graduation deals with the articulation of academic and other forms of knowledge	**K: Knowledges** How are different knowledges mobilized?	*Considers only academic or non- academic knowledge (vernacular, vocational, from media...)*	*Juxtaposes several different knowledge elements (either academic or non-academic)*	*Links socio-scientific knowledges but with coherence limited to one perspective on the problem*	*Links socio-scientific knowledges, acknowledging the possibility of coherence of divergent perspectives.*
The graduation deals with the expression of epistemological doubt and the contextual nature of knowledge claims	**U: Uncertainties and risks** Are the conditions of validity of knowledge and the techno-scientific risks grasped?	*Doesn't perceive any lack of information. The assertions are presented as truths.*	*Recognizes that competing claims about the issue draw upon multiple sources of information.*	*Envisages the need to coordinate multiple sources of information to evaluate competing claims about risk or competing solutions.*	*Explicates the need for knowledge claims to be interpreted in a particular context, to reduce the uncertainties or to estimate the risks*
The graduation deals with the explication and clarification of value positions.	**V: Values** Is there an awareness of the values involved in the issue?	*Shows no awareness of the value or the beliefs underlying the selected arguments*	*Identifies the values underlying the selected arguments*	*Explicates the values central to the conflict*	*Articulates a personal value position that acknowledges the range of values or principles at issue.*
The graduation deals with the potential for regulatory processes that enable citizen participation in balancing interests	**R: Regulation** Are the relationships between private and collective interests considered for a variety of social institution (family groups, peer groups, professional groups, associations, public institutions, nations)?	*Doesn't consider the need to take account of different stakeholder concerns*	*Envisages solutions imposed on stakeholders*	*Envisages active participation of different stakeholders in an open regulatory process*	*Critically analyses possible regulatory procedures between social institutions.*

Table 1: Levels of the dimensions of the S3R analysis model.

biotechnology (breeding, production of muscle cells in vitro) is developed.Two interesting trends appear in the collective construction of reasoning:

1. The contribution of shared experience. In the first wiki, each team tended to consider the SAQ in their particular context, but extended their understandings to other contexts after the international forum, thus enriching their reasoning.

2. The interest in developing arguments was driven by the different positions, leading to a common position in both groups. The quality of the conclusions in the second wikis tend to highlight the importance of consciousness raising, information, and consumer empowerment. Such awareness from future teachers of their educational role beyond the transmission of academic knowledge is, in our view, a significant element of professional growth.

The effect of the context

The effect of context on reasoning could be seen in the differences in the French and Australian wikis on desalination, where the French tended to take a global, somewhat distanced environmental perspective on the issue while for the Australian students local knowledge of the drought and the importance of water supply, and awareness of the many facets of the issues surrounding the government's commissioning of the large Wonthaggi desalination plant, meant their wiki reflected a more diverse range of perspectives and knowledge. Context thus played a part in the quality of reasoning through a) knowledge of the different stakeholders and their positions and b) personal perspectives on the significant of the issue.

The quality of the forum discussions

The exchanges in the International forum showed a genuine attempt to engage with the others' point of view and to achieve a more integrated perspective on the issue. We found we could trace the increased quality of reasoning in the second wiki to specific aspects of the forum exchanges, which appeared then in the arguments considered.

At a more general level, we used an instrument we had developed previously (Morin et al. 2012) to evaluate the quality of the forum discussion. This was based on a combination of the work of Habermas (1987) concerning the validity claims in argument, and that of Mercer (1995, 2000) concerning the orientation of talk, which can be disputational, cumulative, or exploratory, the higher level of which is aimed at integrating the different viewpoints. Habermas talks of three 'lifeworlds' on which validity claims are made: a) the objective world, based on scientific and technical 'truths', b) the social world, based on social norms, and c) the subjective world based on personal experiences.

Examples of the forum discussion for desalination provides an explication of what such an analysis looks like, and show the importance of local context in the forum discussions on desalination.

Integrative talk:

> *While reading through your wiki I noticed you used rain water as one of your main points, but how viable is this? Australia has a lot of drought so there is no guarantee of rain. People also sometimes are unable to afford water tanks or unable to build one in their house. What is your solution?*

Arguments from personal experiences (the subjective world):

> *I know my class mates and my self have all lived through periods of drought and have dealt with water restrictions and witnessed some very depressing scenes including starving live stock and dried out football ovals, however, in the last few years we have also witnessed extreme rainfall.*

In our 'interactional socio-scientific reasoning' framework which measured the quality of forum discussion, the highest levels of reasoned discussion occur when arguments are made on the basis of all three of Habermas's lifeworlds, and the talk is integrative. That is, participants try to understand the positions of others in the discussion and attempt to come to some accommodation in an overall position. We will be reporting on the full analysis in a subsequent paper, but we have been able to show that increases in wiki reasoning are linked to high-level forum discussions.

The effect of cross cultural discussions

As can be seen from the quotes above, the effect of context and culture was an important element in raising the level of reasoning. The wider set of perspectives opened up by differences in the Australian and French wikis and pursued in the discussion, had the effect of deepening thinking about the different aspects of the SAQ. The two examples of Figure 2 show the Australian students operating at an initially higher level than the French students. One of the Australian students argued in the individual reflection, that their initial (Meat A) wiki already reflected a diversity of cultural opinion because of its multi cultural makeup and considerable life experience, some of it international, within the group. We intend to test this assertion through analysis of the initial discussions of the different groups. The higher initial level of reasoning in the Salt B Australian wiki we take to reflect greater familiarity with and commitment to desalination as a complex and important SAQ.

Vive la difference!

We contend that an important factor in raising the level of reasoning in this activity was the staged process of coming to a group position on the SAQ and then needing to reconcile this with a different position. Through the analysis of the forum discussions and wikis, it seemed to us that this dual process, involving groups representing to some extent different cultural and contextual stances, was powerful in eliciting reasoned argument of enhanced quality.

In a previous, similar study involving groups of French students within the University of Lyon, the forum exchange failed to result in improved quality of reasoning in the second wikis, because there were not substantial differences between the points of view of the two French groups. It is difference that drives the quality of reasoning – the need to more sharply explicate and support a position, or to accommodate a range of viewpoints in a more nuanced position following discussion. It has been argued that the fundamental purpose of reasoning is argumentative (Mercier & Sperber, 2011), in which case it makes sense that having positions to argue against or accommodate is an important indicator of reasoning.

Lawrence Kohlberg developed a framework of stages of moral development that is not dissimilar to the levels in our reasoning framework, moving from absolutist positions to concern for the principles and values underpinning a good, democratic society. Kohlberg (1981) argues that the growth through these stages occurs through challenge and debate about moral problems. The consideration of opposing evidence is central to advancing moral reasoning, consistent with our experience here.

Experience of the Australian students

The Australian students, in their reflection, commented on many aspects of the process of wiki development and the forum exchanges. Their views were often critically informed and layered, and they shared an appreciation of the experience and what it had yielded in quality of thinking and as a powerfully educative strategy:

> *Communicating with French students in the international forum has been a great learning experience. It has opened my eyes to cultural differences, including my own biases and opinions*
>
> *I found it very interesting that everyone's idea differed during the forum and I believe that the reasons are because of cultural, social, educational and life experiences*
>
> *Throughout this entire task it was extremely evident that our opposite locations in the world completely affect our views on the topic [...it] shows us the value of education from multiple sources and this has enriched my understanding & the way in which I will teach my own classroom one day*

The social interaction and collaboration between the students facilitated deeper thinking about the socio scientific issues and a disposition to actively engage:

> *Before this course, I have never really considered my personal meat consumption as having an impact on the environment and sustainability issues. The discussion and wiki construction on meat consumption has made me and the other students involved more aware of the impact of meat production on the environment*
>
> *Personally I was shocked at the treatment of animals in factory farms and will now endeavor to buy only free range eggs and pork products for my family*

From our observations, the Australian students learnt to be appreciative about different perspectives as they became: open to new ideas; tolerant towards each other; engaged in their level of discussion; interested and curious about French culture; critical about their local problems; and aware of their own values.

By participating in the international exchange forum, Australian students experienced a more critical and reflecting learning process by discussing their views and ideas in comparison to regular courses. We strongly believe that this educative strategy helped students not only to find and acquire new information about a specific socio scientific topic, but to discuss and reflect on a higher level of reasoning about the topic by sharing it. According to Vygotsky (1978), humans use tools that develop from a culture, such as speech and writing, to mediate their social environments. He focused on the connections between people and the sociocultural context in which they act and interact in shared experiences. Through this educative experience, Australian students were able to confirm their knowledge by first sharing their own views and ideas within a cultural context, secondly they enriched their ideas when discussing their views with the French students, and thirdly they modified their ideas and/or built their own opinions once they've learned from the others. According to Bandura (1977) people learn from one another, via observation, imitation, and modeling. Social learning theory explains human behavior in terms of continuous reciprocal interaction between cognitive, behavioral, and environmental influences. Social interaction and collaboration are essential components of situated learning — learners become involved in a 'community of practice' which embodies certain beliefs and behaviors to be acquired (Lave, 1988).

Conclusions and Implications

This study resulted in a number of findings. First, we were able to develop, and show the validity of a socio-scientific reasoning framework for describing quality reasoning in a group wiki production. We were able to also further validate our interactional reasoning framework applied to the group forum discussions although this was a minor aspect of this paper.

Second, we demonstrated the growth in reasoning within the second wiki development following exposure of groups to each others' considered positions, and link this to: the quality of discussion in the cross-cultural exchanges; the importance of difference in perspective in driving quality reasoning, and particularly; the value of cross-cultural exchanges in broadening and sharpening students' perspectives on socio-scientific sustainability issues. Third, we demonstrated the value that the Australian students placed on the experience and the viability of the approach pedagogically.

The importance of socio-scientific issues within contemporary science curricula makes these findings particularly significant. In Australia, the focus on scientific literacy, reflected in the Australian Science Curriculum in the *Science as a Human Endeavour* strand, is consistent with the concerns that drove our study of SAQs. We argue that this approach to discussion of SSIs is readily translatable into school classrooms, at secondary or even at upper primary school levels.

Teachers of science are not generally trained in running open discussions on SSIs that involve social and ethical questions. Our method provides a staged and productive way of running such discussions in classrooms, and through the frameworks, an elaboration of the reasoning characteristics that teachers should look for and encourage in challenging and supporting students. We found that in preparing the wikis, groups initially divided up the task into discrete bits to produce initial text. With encouragement from the teacher however the group members began to interact, in a second phase, commenting on each other's contributions and coming to a shared position. The whole process took 2-3 hours of class time, together with online searching and discussion time, which could be reasonably set for homework in a school setting. We are convinced that the method is practically do-able in a school.

The cross-cultural exchange is also within the reach of contemporary Australian schools, given improving

access to the internet, and the fact that schools often have international links, and in many cases online discussion forums with other schools either within or outside Australia. While our teacher education students showed a high degree of sophistication in much of what they developed, school students could interact meaningfully with a variety of SAQs with information pitched at their level. Thus, we argue this cross-national exchange approach could be successfully adapted to schools, to support students' reasoning about socio-scientific issues.

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