Affirming the Value of Science by Acknowledging the Social and Personal Identity Formation of Year Eight Science Communicators: An Evaluation and Suggestions for Improvement of an Existing Unit on Ecology

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Abstract: *People live a better quality of life if they know about science, but how does the communication of science affect the public's understanding of these issues? Perhaps if students were scaffolded to become science communicators, they would not only learn about science, the content, but for science, the social purpose, while gaining a wider understanding of their own personal identity formation. This paper addresses these issues with respect to curriculum review and development by reviewing a Year 8 Ecology Unit from Melbourne Girls' College in Australia. This context provides an example of strategies that might be used by educators to deconstruct existing curriculum using a SWOT analysis and suggests approaching the teaching of science to be developed through an E5 framework while focusing on key concepts and students' misconceptions. Selected student activities and projects from the unit will be examined with respect to the motivation behind the topic, personal identity formation, acknowledging the social in science and the idea of popularization, while at the same time guiding students to become aware of effective science communication by engaging with and in it.*

Key words: Science communication, E5, scientific misconceptions

Introduction

The title of this paper alone is a mouthful! Before unpacking the unit and explaining the suggested improvements, I want to share with you an experience from a year nine Forensic Science elective which got me thinking about science communication. While discussing how to go about testing blood samples the following dialogue took place:

Student 1: What happens if we mix two samples of blood?

Teacher: Good question, anyone have any thoughts?

Student 2: It would get AIDS.

Teacher: What do you mean by that? What would get AIDS?

Student 2: By mixing the two samples, we would make AIDS.

Teacher: Humm… Is that how AIDS comes about?

This discussion went on for some time, what was striking to me was that this student as well as others seemed to possess some interesting misconceptions – immature understandings which serve as an adequate construction of the world at a certain time and place – about a highly publicized and socially relevant topic. How is it that such a pertinent issue, especially one so important for young people to be aware of, could be communicated so poorly? In my opinion, people live a better quality of life if they know about science, but how does the communication of science affect the public's understanding of these issues?

Perhaps if students were scaffolded to become science communicators themselves, they would not only learn *about* science, the content, but *for* science, the social purpose, while gaining a wider understanding of their own personal identity formation. In order to illustrate this point, I have chosen a Year eight unit on biology from an existing curriculum at the same school. In this paper, the unit will be introduced and unpacked with respect to the strengths, weaknesses, opportunities and threats. Selected student activities and projects from the unit will be examined in the context of the E5 framework with respect to the motivation behind the topic, personal identity formation, acknowledging the social in science and the idea of popularization, while at the same time suggesting improvements for students to become aware of effective science communication by engaging *with* and *in* it.

Unit Overview and SWOT Analysis

The unit chosen for evaluation is a year eight unit on ecology. Topics investigated by the students include classification, ecosystems, predator/prey relationships, adaptations, conservation issues and biodiversity. The unit should take just over a term to complete, approximately ten to twelve weeks with four lessons of seventy minutes each week.

This SWOT analysis identifies the strengths and weaknesses within the unit as well as the opportunities and threats that exist externally to the unit with respect to engaging students *with* and *in* science communication. The points brought up in this chart will be elaborated on with specific examples from the text in the following sections.

Strengths	**Opportunities**
- students are learning *about* science, content - students are forming communities in which they are communicating with each other - there is regular use of ICT, video and external articles connecting students to a wider community of scientists - there is an element of agency	- integrating and acknowledging the social experience in science - illustrating that there are many views regarding the understanding of the natural environment and humanity's relationship to it - integrating resources not traditionally used in the science classroom that may have value and appeal to a variety of learners

Weaknesses	Threats
- the structure of the unit does not illustrate the overall scientific concept being studied - the starting point does not allow for students to locate themselves in the topic - there is a lack of emphasis on the social experience in science - the text positions students in such a way that they do not critically unpack different social constructions of the natural environment held by a variety of stakeholders - the ICT activities, video and eternal articles mostly focus on recall - the element of agency could be tokenistic	- pressure of introducing science communication and scaffolding students through the subject content - seeking alternative resources takes time and effort - introducing popular science articles may be seen as beyond the reading levels for the students

What's The Big Idea?

Mentioned earlier were the topics to be investigated by the students which include classification, ecosystems, predator/prey relationships, adaptations, conservation issues and biodiversity. Flipping through the pages of the student booklet, however, I found myself wondering what is the big scientific concept being addressed by these topics? After completing this unit, would students have a clear understanding of how this big idea comes together with respect to the topics?

In a discussion on progression of reasoning about ecosystems, Driver et. al. (1994, p. 56) point out that:

> There is a trend from the egocentric (self-centered) thinking of very young children, through anthropocentric (human-centered) reasoning, to the reasoning which includes a wider range of factors shown by older students. Teleological reasoning is common in young children…

For this unit, it is proposed that the overall scientific concept that should be addressed is the departure from the egocentric, anthropocentric and teleological constructions of ecosystems students may hold on to and move to a more sophisticated understanding of ecosystems. Students should understand ecosystems as being shaped by the relationship of living organisms to each other as well as non-living elements of the environment and suitable habitats allowing them to thrive while at the same time being aware that ecosystems are in flux.

Unpacking the Unit in an E5 Framework

In this section, I have chosen to unpack the unit in the E5 framework. It should be noted that the suggested activities provided with the evaluations of the existing unit are meant as an inspiration for improvement, and it is acknowledged that a diverse range of activities could be employed for different cohorts of learners. I have chosen to group the Explain and Elaborate stages of the E5 model together because the E5 framework should not be understood as a linear process. For me, the Explain and Elaborate stages are understood as being intertwined and in a cyclical relationship. I like to think of their relationship as being akin to tai chi – the Chinese sport of pushing hands which teaches the body to yield to force and redirect it. In the E5 framework, students are yielding to information in the Explain stage and redirecting it in the Elaborate stage, another cycle of pushing hands yields more information to be redirected and evaluated and so on.

Engage

A logical place to start any teaching is the engagement of the individual with the topic. Students need to think about themselves and locate themselves within the topic and potential issues surrounding it. Perhaps it is a good idea to start with an activity that relates to prior knowledge and experiences as well as attempting to answer the question: Who am I in this subject? Exploring these topics is imparting the known to the unknown and takes the students to the boundaries of their current epistemic constructions of the subject and readies them for the puzzlement which will challenge them to form more complex understandings.

The first activity of the unit is a video presentation about the Arctic. Although engaging, there has been no attempt to allow the students to explore their own location within ecology which addresses their current relationship with the subject or their current understandings of the overarching scientific concept being addressed, the complexity of ecosystems. For this reason, I propose an activity that has been adapted from a university course in environmental education which can be completed as an introductory lesson to ecology. Students make posters about relationships between living and non-living things and how these relationships affect them, see Appendix I. By hanging the posters around the classroom and having students look at and discuss them together, they are confronted to share their own and their peers' current understandings of ecology as well as demonstrating the subject specific terminology they currently possess. The teacher can also gain insight into how the students' social and cultural networks have positioned them to form their current understandings. Allowing students to articulate their current location in a topic will facilitate them to move on to exploration.

Explore

How often can science classes explore scientific ideas in context? Excursions and camps can be time consuming and costly to both schools and parents. One method to combat these costs is to bring video into the science classroom, the genre being documentary. This unit makes use of video on three occasions. Although video can provide insight to situations inaccessible to students, the questions they are expected to answer in this unit focus on recall or drawing out of factual answers which in my opinion affirms students' view of science as a static understanding of the world in terms of right

and wrong. Furthermore, there is a lack of connection to the social experience in science and an underlying assumption that humanity is separate from nature.

In order to create richer learning experiences for students using video, specifically documentary, curriculum writers must provide opportunities for students to reflect on the ideas and scientific concepts in videos in relation to cultural constructs. An example of how one might do this is presented in Appendix II, in which a documentary is juxtaposed with a feature film to deconstruct a native Canadian group's integration in an ecosystem in Northern Canada. By scaffolding the students to critically explore scientific ideas in context via comparison of information presented in media designed for different purposes, control has been handed over to the learner to guide them in constructing their own meaning with the use of scientific language while highlighting the integration between science and society.

Does using video bypass the overall scientific concept addressing the complexity of ecosystems? This depends on the agenda of the video as much as the activities students undertake to grapple with the content. For example, the first video in this unit, *Arctic Kingdom,* presents an ecosystem which is simple and may be seen as untouched enforcing a view that ecosystems are not complex entities. Girffiths and Grant (1985, cited in Driver et. al. 1994, p. 63) warn that presenting food chains, as shown in the video *Predator and Prey,* before food webs fails to illustrate the interdependency of relationships in complex ecosystems. Educators must be aware of and scaffold students to realize the hidden agenda behind these forms of media and structure curriculum in such a way that does not lose sight of the overall picture.

Explain and Elaborate

The danger surrounded in the explain stage of this framework comes from using texts which are deemed as safe by providing simplified representations of scientific information to students in order for them to 'get it' and elaborate on it.

The Australian Academy of Science and other sponsors have put together a series of articles which investigate the science behind the headlines published online under the title *NOVA: Science in the News.* The unit makes use of this source by providing students with an article from NOVA called *Weeds – the real alien invaders*. I was intrigued that the authors contributing to NOVA investigate the science behind the headlines, but also wondered why students were not given the opportunity to explore example articles from popular media as well.

The suggested activity I propose to enrich the learning experiences in the current unit involves scaffolding students to critically read and engage with media articles, complemented by peer reviewed resources, see Appendix III. Educators must draw students to the realization that science is a dynamic process and in order to be effective science communicators themselves, students must be aware of this and be directly involved *with* and *in* science communication. In this way, students are still achieving the strengths of the original unit by forming communities and exchanging information with each other, but also drawing on opportunities by making use of external articles, addressing the social experience in science and reflecting on their personal identity formation by investigating other people's views.

Bringing in external articles from popular media sources poses a potential threat to the overall science concept of the unit. Instructors must not lose the focus and provide

media articles that diverge from illustrating the complexity of ecosystems unless students are adequately scaffolded to comment on these issues.

Another danger of the explain stage exists in positioning students by the content chosen to be introduced. For example, one of the hurdle tasks students attempt as part of the unit deals with research of and presentation to peers about conservation issues. Although this activity encourages agency by creating awareness about a conservation issue and even going so far as suggesting to join a conservationist group, the task positions students in such a way that they come to conceptualize nature through a balance of nature paradigm thus losing the focus of the unit.

In their paper The *(Im)balance of Nature: A Public Perception Time-Lag?*, Ladel and Gillison (2009, p. 230) report that there is a balance of nature metaphor that is held in the popular media but that a more dynamic vision of the natural world is taking hold in academic communities, the flux of nature. Ladel and Gillison suggest that environmental science communicators inform the public that ecological resilience has limits and that agreement over where those limits exist is the topic of scientific debate (2009, p. 239). Although part of the assignment alludes to a flux of nature, one of the outcomes is to describe the complex interactions of living things in an ecosystem; students are not scaffolded to understand that there are two distinct paradigms of nature. Examples of ecosystems in flux need to be brought to students' attention; the salmon migration from their coastal waters is one instance that comes to mind.

Another interesting dimension to this inconsistency is brought up by Fleishman (2003, p.555), quoted in Bonnett, 'nature has no problems… conservation is based on human value systems with no *biological* reason for it.' Students can be scaffolded to understand this human construction by discussing reasons why conservation is valued. Bringing students' attention to the two paradigms of nature as well as illustrating that conservation is a human construction is an opportunity to illustrate that there are many views regarding the understanding of the natural environment and humanity's relationship to it without losing the focus of the unit.

Evaluate

The final stage in the E5 framework, Evaluate, is where students can become empowered by reflecting on their own learning and new understandings of the world while being challenged to provide evidence for changes in their belief system. It is an expressive and powerful stage.

The unit's *Biodiversity for Kids* assignment challenges the students to assemble the information and new understandings constructed from this unit into a children's storybook designed to teach primary children about biodiversity. Students are now being asked to take their learning *about* science and translate it to learning *for* science, the social purpose.

According to the student booklet, 'Although humans generally have a negative impact on biodiversity, you can also have a positive one', this statement taken as a given misses the opportunity for students to reflect on previous activities completed as a class and indirectly suggests that the understandings formulated are anachronistic. Alluding to previous activities models the importance of making connections with past experiences and reflecting on them to evaluate new ideas, see Appendix IV.

The description of the task points out that '… the text [the language in the story students write] must be relatively simple.' What does it mean to be relatively simple? Here is an opportunity to integrate resources not traditionally used in the science classroom that may have added value to the construction of scientific concepts as well as literacy.

In her article *The Synergy of Science and Reading*, Coskie (2006, p. 63) concludes that "… integrating reading and science holds promise for improved student achievement. Programs designed to explore the integration have shown that students are motivated to engage in the work." Although Coskie is writing to an audience of elementary teachers, I argue that the same can hold in the secondary classroom. Taking this into consideration, I propose that students can be scaffolded to understand the meaning behind 'relatively simple text' by revisiting a children's story they may have already read, *The Giving Tree* by Shel Silverstein. A closer look at the sentence patterns and pictures of the story book can allow students to unpack the text with respect to the broader scientific concepts that they have been studying in this unit while bringing to their attention the importance of simple text and use of images to construct greater meaning, see Appendix IV. For example, students may be puzzled and say that the relationship between the boy and the tree is either mutualism or commensalism. The text and pictures in *The Giving Tree* suggest that it is mutualism – both organisms benefit from the relationship – because the tree has human characteristics, she 'loves' the boy. This brings us back to the topic of scaffolding our students to become effective science communicators, the very nature of this assignment.

Sackes et. al. (2009, p. 421), point out that texts with misconceptions and inaccurate illustrations can be turned into learning opportunities by discussing the actual versus the represented events in children's books. Similarly, Gomez-Zwiep and Straits (2006) adhere to the idea that anthropomorphic texts provide opportunities for meaningful scientific learning while developing students' understanding of different genres. For the purposes of scaffolding students to become better science communicators, I propose that time be spent deconstructing a piece of literature can allow the hidden agenda of the science presented in popular media to be revealed while at the same time relating it back to the concepts of ecosystems, this text for example presents a balance of nature paradigm. Students have already been given the opportunity to investigate science communication in the media but providing them with the opportunity to investigate this in another genre of communication, and one they are relatively familiar with, provides them with a more holistic understanding of the realm of science communication and better prepares them to tackle the project of writing their own children's story.

A final point for consideration when dealing with curriculum which allows for agency is that science communication must be genuine for students. It was suggested that an added goal to the ecology unit was education *for* science by engaging students *in* science communication. The description of the *Biodiversity for Kids* assignment suggests that students *may* be asked to take their children's books to the local elementary school and read them to a class. Last year, when I observed this unit being taught, students did not have the opportunity to visit the elementary school and share their work, thus making a genuine communication opportunity for students tokenistic. This is a threat that will be discussed in the following section.

Conclusion

In his construction of the epistemic authority for teacher knowledge, Roberts (1996) provides a useful diagram illustrating the body of knowledge from the domain, in this case ecology, its relation to both teachers and students and the nature of communication *between* teachers and students. The following diagram is an adapted version of Roberts' triangle, the Trialogue style of teaching, and serves to illustrate how the suggestions posed to this unit of work encourage scientific literacy through science communication.

At the point in which communication occurs, I suggest a small adaptation to Roberts' triangle; I have chosen to represent the arrows as equilibrium arrows found in chemistry. Communication should be in equilibrium, the forward and reverse reactions are occurring at the same rate. This is meant to illustrate that communication should not be dominated solely by the teacher. If this were the case, it would not foster a community of inquiry and would fail to illustrate that science is a dynamic process. Similarly communication should not be dominated by the student because the clarity of the scientific concept could be in danger, not endanger pun intended, of being lost.

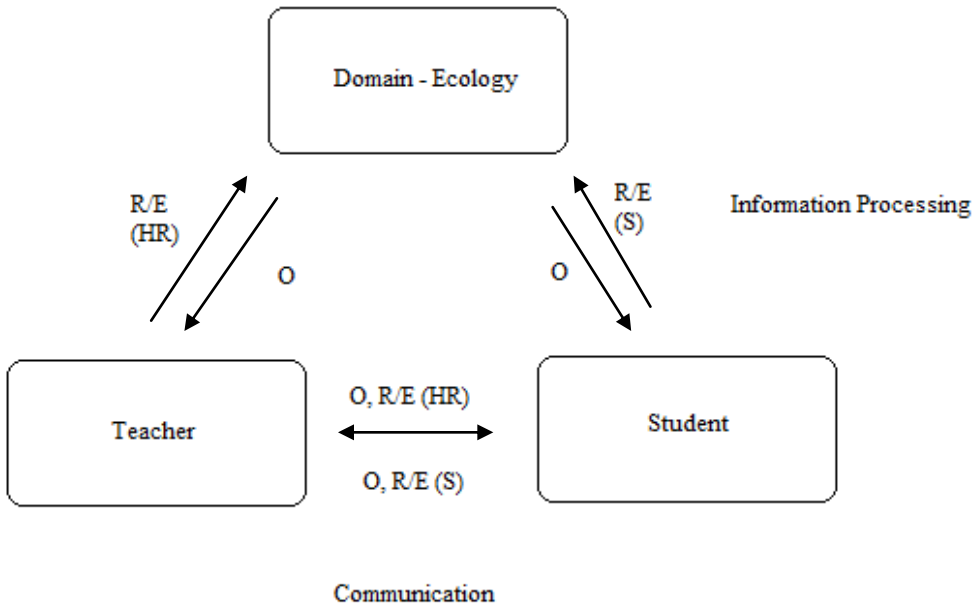

Figure 1: Roberts' triangle, the Trialogue Style of Teaching
O = obsertvations; R/E = representation and/or explanation;
S = by the student; HR = by others of the human race

Adapted from Roberts (1996)

In this style of teaching, the student observes the events of the domain while at the same time bringing their own constructed representation or explanation of it. Roberts asserts that the existence of the student's prior conceptions is acknowledged and that their legitimacy at the level of understanding is taken as a given (1996, p. 422). Initially this

unit on ecology did not provide a starting point for students' prior knowledge to be acknowledged, however with the introduction of an activity in the Engagement stage of the E5 framework, this problem was addressed and students were drawn into the overarching scientific concept of the unit.

According to the Trialogue style of teaching, the students must have the opportunity to compare what the teacher has to offer as justified knowledge on behalf of other people's efforts to construct representations and explanations of the domain (1996, p. 422). My evaluation of this unit has found that though other people's representations were alluded to, they were not investigated in depth to give students an adequate opportunity for comparison and construction of new understandings in a framework of science communication.

The purpose of this paper was to propose that if students were scaffolded to become science communicators themselves, they would not only learn *about* science, but *for* science, while gaining a wider understanding of their own personal identity formation. Burns et. al. have suggested that developing literacy in an area of science can be compared to climbing a mountain in that it is dynamic, participatory and ultimately changes the participant's view of the world. They assert that the climbing process is facilitated by science communication (2003, p. 192). For me, someone who is scientifically literate is a person who can make informed choices and become an active member of society in which behaviors are shaped by a body of scientific knowledge. In this paper, I have deconstructed an existing year eight unit on ecology and made suggestions for improvement to scaffold students to have a better understanding of science communication and engage with it while concentrating on the concept that ecosystems are in flux. I acknowledge the warning from Burns et. al. (2003, p. 192) that science communication will not always produce an increase in scientific literacy, but argue that guiding students to be more aware of science communication can inspire inquiring minds to become more scientifically literate.

I realize that added threats to the success of the unit can arise by evaluating it and suggesting improvements to be made. Seeking alternative resources takes time and effort, and in the busy atmosphere of the school community the teacher's time is often stretched to the limit. For these reasons, I have tried to include wherever possible specific references to materials that may be added. The other major threat to this unit's success is the pressure that teachers often feel to get through course content. Introducing an added element to the content, scaffolding students to become science communicators, puts further pressure on classroom time. However, if becoming aware of science communication and their role *with* and *in* it, students would be better scaffolded for making life decisions for the skills that a scientist uses, are truly worthwhile life skills.

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Appendix I: Engage – An Introductory Activity

Students might be given an A3 size page of paper as well as several different colors of other paper, a pair of scissors and some glue. They could be asked to make a poster about relationships between living and non-living things and how these relationships affect them and each other using only these materials – no pencils or rulers. The posters should be hung around the classroom and students given time to look at and discuss them. Teachers facilitating the discussion should model language that encourages students to share their ideas in a safe environment; such as: Why do you think that? Some people say… does that fit your idea? What do you mean by that? In my experience modeling this language results in students beginning to use it in their own conversations.

Appendix II: Explore – Juxtaposing Documentary with Feature Film

Arctic Kingdom – Life at the Edge highlights the relationship of the fauna with this environment and provides a quick snapshot of the Inuit people. The purpose of this video is to inform the viewer about scientific concepts relating to ecology. I propose that this video be juxtaposed with the 2001 Canadian film *Atanarjuat: The Fast Runner* directed by Zacharias Kunuk. This film is set in the ancient past and recounts an Inuit legend passed down through oral tradition while showcasing the unique relationship that these people have had and in many ways still have to the natural environment. Many of the cultural constructs and ways of life still play an important role in these communities even though a cultural exchange between Inuit and mainstream Canadian culture has and is still taking place; this is a subject for future papers investigating a cross-cultural approach to teaching science.

Some examples of supplementary questions that could be included for discussion are:

How might the environmental conditions of the Arctic affect the people living there?

What role did cracks in the ice play in Atanarjuat's escape from Oki?

How might cracks in the ice affect life for the Inuit?

How do humans feature in the food chain?

The Inuit seem to have a close connection to the environment, explain this with an example of what you saw in *Atanarjuat: The Fast Runner*.

Appendix III: Explain and Elaborate – Complement to NOVA

Weeds – The Real Alien Invaders discusses the serious problem of invasive weeds endangering biodiversity in Australia. It touches on the economic and environmental burden that weeds place on agriculture and preventative measures in the form of biological and cultural control. The article ends with a biological control success story. I suggest that the current NOVA article introduced remain in the unit but be read and discussed along side the opinion piece called *Living with Aliens* by Mark Davis in the September 26th, 2009 issue of NewScientist. This article provides an alternative view of non-native species and contrasts viewpoints held on the subject by different groups of scientists while touching on scientists' communication with the public.

To engage students *in* science communication, students comparing these articles might perform a role play in which they assume the identity of different stakeholders involved in the issues of introduced species; for example the following roles might be considered for this activity:

- scientists adhering to the nativism paradigm
- scientists claiming that introduction of species is relatively benign
- farmers dealing with the affects of harmful weeds
- boarder control officials involved in cultural control of introduced species
- people suffering from allergies due to weeds

Students could work in groups assigned to one of these stakeholders and discuss other people's views and formulate rebuttals based on what their assigned stakeholder might say or do. The teacher should assume the role of facilitator and ask the students to think about the provided questions from the unit referred to above and become familiar with the ecological terms that this unit introduces; such as biological control, cultural control, out-competition, extinction, etc, as part of their rebuttals. A class discussion could then take place in the form of a town hall meeting debating what to do about an invasive weed.

Appendix IV: Evaluate – Unpacking *Biodiversity for Kids*

Connecting and Reflecting on Past Experiences

I propose that students are asked to unpack the following statement found in their booklet: 'Although humans generally have a negative impact on biodiversity, you can also have a positive one…' to better engage them with this task. Some questions that might be posed for discussion include:

> What do we mean by 'generally?'
>
> What do we mean by 'negative/positive impact?'
>
> Can you give and an example of and explain a negative or positive impact humans have had on biodiversity? Have a think about the film *Atanarjuat* and what we learned about invasive species.

Scaffolding Students Through *The Giving Tree*

The book opens with the following:

> Once there was a tree,
> And she loved a little boy.
> And he would gather her leaves
> And make them
> Into crowns
> And play king of the forest.

In the picture, the boy is gathering falling leaves from the tree. The teacher might prompt students to connect this scenario with previously studied scientific concepts by posing questions such as:

> How is the boy collecting the leaves?
>
> What does he do with them?
>
> Who or what is benefiting from this?
>
> Does this remind you of a relationship that occurs in ecosystems?