

Philosophical Aspects of Socially Responsible Science Education for Sustainability

ابعاد فلسفی آموزش علوم با مسئولیت اجتماعی برای دستیابی به توسعه پایدار

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This paper presents an overview of the philosophical assumptions supporting socially responsible education for sustainability and its links to ethical dilemma story pedagogy by exploring the underlying philosophy and presenting its practical applications in our research. Socially responsible education for sustainability aims at bringing together education for sustainability and education that promotes social responsibility by marrying traditional subject specific, content-based education with ethical considerations drawing on strategies from values education. Ethical dilemma stories have been successfully applied in values education for over forty years and have been shown by our research to be particularly suitable to address values and ethics in the context of science- and sustainability education. The integral philosophical framework employed in our research combines three types of ethics including: an ethic of fairness or justice, an ethic of care and an ethic of consequences. This integral approach seems to be particularly suitable for supporting pedagogies that use ethical dilemma stories to engage students deeply in reflection on their values and in collaborative exploration of ethical dilemmas. All three types of ethics are required if this type of values education is to be balanced. To illustrate further the applicability of this integral framework I provide a review of our research on this topic conducted over the past few years.

Keywords: education for sustainability; ethical dilemma stories; values in science education

مقاله‌ای حاضر مروری بر فرضیه‌های فلسفی که پایه و اساس آموزش با مسئولیت اجتماعی برای دستیابی به پایداری (تحمل‌پذیری) و ارتباط آن با آموزش از طریق داستان‌های معضلات اخلاقی می‌باشد. این مقاله هدف خود را از طریق بررسی زیرساخت‌های فلسفی و دلالت‌های عملی آن دنبال می‌کند. آموزش با مسئولیت اجتماعی برای پایداری (تحمل‌پذیری) با ایجاد پیوندهایی میان آموزش سنتی محتوا محور با موضوعی خاص و ملاحظات اخلاقی که از راهبردهای آموزش ارزش‌ها بهره می‌جوید در پی تلفیق آموزش برای پایداری (تحمل‌پذیری) و آموزشی که به ارتقاء مسئولیت اجتماعی می‌انجامد می‌باشد. چهل سال استفاده از داستان‌هایی با محتوای معضلات اخلاقی در آموزش ارزش‌ها موفقیت‌هایی در پی داشته است و مقاله‌ای حاضر نشان می‌دهد که این موفقیت‌ها به لحاظ عملی برای مد نظر قرار دادن ارزش‌ها و اخلاقیات در بستر آموزش علوم - و آموزش پایداری (تحمل‌پذیری) - مناسب و کاربرپذیر می‌باشد. چهارچوب فلسفی مورد استفاده در این مقاله شامل سه نوع اخلاقیات است: انصاف و عدالت، مواظبت و مراقبت، و پی-آمدهای اعمال. این رویکرد تلفیقی خصوصاً برای آموزش‌هایی که در آنها از داستان‌های حاوی معضلات اخلاقی به هدف ترغیب و تشویق فراگیران جهت تأمل پیرامون ارزش‌هایشان و مشارکت در بررسی جمعی و گروهی معضلات اخلاقی استفاده می‌شود مناسب به نظر می‌رسد. برای ایجاد تعادل و توازن در آموزش ارزش‌ها باید هر سه نوع اخلاقیات ذکر شده مد نظر قرار گیرند. برای روشننگری بیشتر پیرامون کاربرپذیری این چهارچوب تلفیقی، مقاله‌ای حاضر مروری بر پژوهش نویسنده را ارائه می‌دهد که در طول سال‌های گذشته در مورد این موضوع صورت گرفته است.

کلید واژه: آموزش برای پایداری (تحمل‌پذیری)، داستان‌های معضلات اخلاقی، ارزش‌ها در آموزش علوم.



Introduction

This theoretical paper focuses on the philosophical underpinnings of socially responsible education for sustainability a form of sustainability education that marries aspects of values and ethics education with science and environmental education. Dilemma-based, content specific and values dependent decision-making forms the core of our socially responsible science for sustainability curriculum. Additional empirical research was conducted supporting this philosophical inquiry (e.g., Settelmaier, 2009). Education for Sustainability has become an issue of global importance: science education amongst the disciplines seems to be particularly suited to provide the necessary knowledge- and skills base for informed-decision-making with a view to a sustainable future yet has often failed to address values and ethics in classrooms. In addition it appears that science is increasingly failing to ‘impress’ young people altogether leading to the question what if anything can and should be done to correct the current trend.

Lacking engagement and lack of proactivity – a disturbing issue

In recent years educators at a global scale have raised concerns about the falling student numbers in science-related disciplines and mathematics. Recent studies brought to the fore the disconcerting levels of hopelessness and feelings of helplessness reported by many adolescents (Fien, 2001). These issues are particularly problematic since these young people represent the leaders and decision-makers of the future and it is their decisions that will need to be both ethically and sustainably sound. The question arises: how does one educate a generation which is challenged by unprecedented global problems? How does one educate young people who seem to have ‘abandoned ship’ before even starting to face the issues? Traditionally the response to these educational conundrums at least in science education has been – if students are not performing well in science they get more science content and more science classes in their curriculum. Environmental content is treated in a similar way – if there is a lack of engagement with environmental issues, students need more content.

Uzzell (2008) explained that there is an underlying, mistaken assumption in educational circles that global crises can be resolved by developing children’s knowledge levels. This belief is based on the assumption that children assume the role of ‘little experts’ when they

return home after school positively influencing their parents to conserve water, save electricity, and recycle – thus changing societies and cultures forever. Unfortunately for proponents of the content plus approach, research funded by the European Union concluded that, “...it cannot be assumed that simply giving children environmental change information and relying on a process of osmosis will lead to enhanced concern and action.” These results have direct implications for how we view curriculum development for science education in the future - curriculum that is successful at enhancing environmental awareness and agency and that encourages future citizens to get involved and active rather than closing down and becoming helplessly reactive.

Education for sustainability and science education

According to Van Eijck and Roth (2007) the demands of high-ranking scientists to improve science education worldwide is an expression of the growing consciousness that high-quality science education is vital not only for sustaining a lively scientific community that is able to address global problems like global warming and pandemics, but also to bring about and maintain a high level of scientific literacy in the general population (p. 2763). They state that, “...effective education can serve as a vehicle for solving global problems (p. 2763).” This sentiment is echoed in Moore’s statement (2006) whose paper focuses on the outcomes of a conference held in Durban in South Africa in 2005 where physicists from all over the world had gathered to discuss the role of science and in particular of science education in relation to sustainable development. One of the demands resulting from the meeting was that “...the problem-solving style of scientists and engineers is a mindset sorely needed for the sustainable development challenges facing developing countries and an ever-increasingly globalised world.” Yet traditionally science has often been taught as if it could and in fact should be value-free (Allchin, 1998; 1999a & b). Science educators often shy away from addressing values because of fear that values are outside the domain of science education. This view is in need of becoming rapidly displaced as societies worldwide realise that everything taught in schools influences how students understand and shape the human culture / natural environment relationship (Bowers, 1993; Orr, 1992). This perspective, fuelled by a rapidly growing awareness of global environmental crises, points to the pivotal role of science education for dealing with values



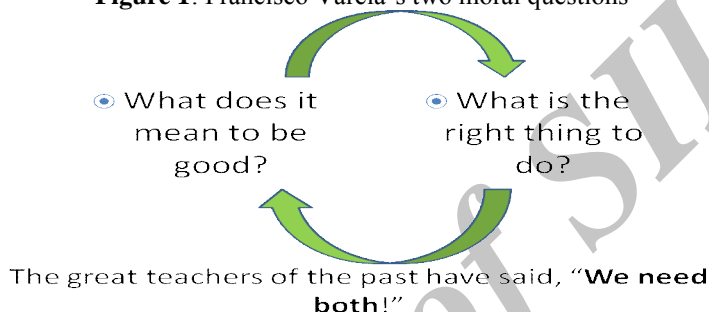
learning issues in relation to sustainability. Furthermore I argue, along with (McInerney, 1986; Zeidler, 1984) that engagement in values learning as part of education for sustainability forms part of scientific literacy for the 21st Century. Pedagogical practice and philosophy of science education for sustainability that employs ethical dilemma story pedagogy can meet all the requirements for successful and effective sustainability education as suggested by Fien (2003). He argues for a reorientation of existing educational practices to include interdisciplinarity, student-centred learning, futures education, education for gender equality, education for citizenship and democratic societies, education for a culture of peace and respect of human rights, health education, population education, education for protecting and managing natural resources and education for sustainable consumption.

Sustainability as a value

In Australia, sustainability is now recognised as a National Priority - an issue of great value to the nation. According to the National Framework for Values Education in Australian Schools, the National Goals for Schooling in the Twenty-First Century - as outlined in the Adelaide Declaration (Ministerial Council on Education, Employment, Training and Youth Affairs, MCEETYA, 1999), argue strongly that Australia's future depends on a solid foundation for young Australians' intellectual, physical, social, moral, spiritual and aesthetic development. Values education has thus been recognised as an essential part of effective schooling in Australia. Sustainability represents a national value that starts with each individual person's values system, with his/her attitudes to the environment and the world's diversity, and his/her ability to make decisions that may impact on the future of not only the nation but the world beyond. Making ethical decisions requires informed decision-making skills based on sound scientific knowledge of the environment, a high level of awareness of the impact of science and its uses, and the ability to engage in critical thinking and critical reflection, thus being able to distinguish between beneficial and potentially detrimental 'decisions'. Thus, it is the task of science teachers to prepare students to participate in an informed and competent manner in the public discourse on science by engaging them in the discourse of science education for sustainability.

Francisco Varela in his work “Ethical Know-How: Action, Wisdom, and Cognition” raised the question as to what is more important: to do good or to be good” (1992). He stated that as soon as you ask the question you enter the realm of moral philosophy, the realm of human values. Thus, asking this question within the context of science education, to call for science education that encourages action is actually an ethical issue.

Figure 1: Francisco Varela’s two moral questions



In religious literature of the past, the great teachers of world history concurred that we always need both – awareness raising and action. They recognised that to simply raise awareness and teach ‘content’ was not sufficient to move learners to take action, change behaviours and values. This is a dilemma for science education where traditionally the emphasis has been on content learning whilst values learning has been left to other disciplines.

Ethical dilemma story pedagogy as a tool for adding value to science education

I would like to argue that science education in the 21st Century must include a discourse on values and the ethical implications of science, the way scientific knowledge is obtained and used in daily life to reignite students’ passion for science learning with a view to solving the world’s problems in relation to sustainable development. Whilst science education has always been good at promoting critical thinking this alone will not do in the future and opportunities for students to come up with creative solutions to problems will become increasingly important. One way of engaging students in critical and creative thinking, in critical self reflection and in dilemmas thinking is ethical dilemma story pedagogy. Ethical dilemma stories go back to Lawrence



Kohlberg who used them in the context of values education. The use of stories as a means to address values learning has always been seen as 'valuable' in many areas of education except for science education where many teachers continue to not recognise this task as the domain of science education despite explicit national curriculum documents that require teachers of all disciplines to contribute to the learning of values. In the following section of the paper I explore some of the philosophical underpinnings of a science education that can promote sustainable development without the need to diminish or water down the learning of science – a concern sceptics of any alterations to science curricula often hold.

Education for sustainability, values learning and science education

Whereas science education focuses on theories of natural laws and phenomena, values education promotes raising awareness about what is dear to us and environmental education adds ecological systems thinking about the wise use of natural resources and conservation. Together they all contribute to what can be referred to as education for sustainability. Education for sustainability aims at promoting all of the above PLUS social, economic, and political responsibility. Education for sustainability that it also socially responsible contains all of the above PLUS demands that any action taken in favour of sustainable development must be accompanied by an attitude of commitment to ensure that the social fabric of a society is respected.

Socially responsible science education for sustainability and Paolo Freire

Socially responsible science education for sustainability encourages students to critically assess available knowledge thereby establishing critical consciousness amongst students and teachers. It draws on Paolo Freire's concept of 'conscientisation' that he described as overcoming a naïve state of consciousness and the insertion of a person into a demythologised reality (Freire, 1998). Issue of myths in science (education) deserve mentioning in this context yet will not be elaborated on further in this paper since this topic has been critically analysed elsewhere in the literature, e.g., Milne & Taylor, (1998); Pitt, (1990); Tobin and McRobbie, (1996). A socially responsible science curriculum for sustainability that addresses ethically contentious issues linked to science and sustainability allows for dialogue supporting

students in becoming aware of the myths in and around science thus promoting their conscientisation in Freire's sense.

Education for 'Mündigkeit' (German: majority, responsibility of an adult)

From this perspective, which is common in central Europe, science educators have an obligation to educate students towards participation in a critical discourse about science thus preparing them for their later adult and professional lives. Students ought to be able to make informed decisions about science-related issues which goes hand-in-hand with what Skovsmose (1994) called '*Erziehung zur Mündigkeit*' forms part of 'Bildung' (German: *formation*; the better translation is more akin to 'holistic education') and regards self- and co-determination and critical citizenship as integral parts of any type of education (Gschweidl, Mattner-Begusch, Neumayr & Schwetz, H., 1998). A person with '*Mündigkeit*' shows the capacity to make well-balanced decisions.

An integral philosophical perspective of socially responsible science education for sustainability

In 1998 Felicity Haynes published her book 'The Ethical School' which suggests a type of integral ethical philosophy that is particularly useful in the context of socially responsible science education with a focus on sustainability. Her model combines three ethical principles:

Principle of Consistency: Subjective aspect of ethics – practice is regarded as intentional. Ethical action is deliberate, chosen, shaped and made justifiable by the coherence of internalised rules, meaning and values (based on Kohlberg's work)

Principle of Consequence: Objective aspect of ethics – practice is regarded as externalised in terms of causes and consequences. It focuses on what can be observed and agreed upon based on scientific or measurable aspects of morality. Teleological view focused on the goals. Actions are assessed with regard to whether or not the goals have been achieved.

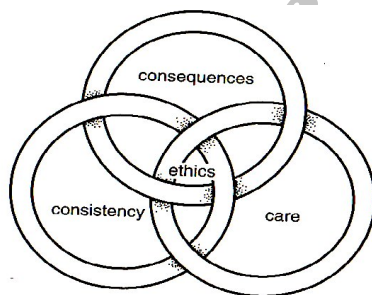
Principle of Care: involves a broad web of relationships and is based on Carol Gilligan's ethic of care. It is holistic and responsive making of reciprocal connections in order to help others in a special act of receptivity (Haynes, 1998).

Haynes refers to her model as the Borromean Knot of Ethics - a metaphor borrowed from Lacan: the image of the model consists of a set of three interlocking rings that would fall apart if one of the rings



was cut (compare Figure 2). Haynes' motivation to use this metaphor is summarised in her statement, "What the Borromean Knot emphasises is the fall from privilege of any of the rings that constitute the knot (Haynes, 1998). For Haynes neither Kohlberg's view of an Ethic of Fairness, nor Carol Gilligans' Ethic of Care, not an ethic of consequences should be privileged. She merges Kohlberg's view on ethics representing a (rather) masculine, subjective view of ethics that is based on the Principle of Consistency, with the rather objective view of on ethics based on the Principle of Consequences, and with Gilligan's intersubjective, (rather) feminine, perspective of an ethic based on the Principle of Care.

Figure 2: The Borromean Know of Ethics after Lacan (Haynes, 1998)



In the book "Adding Zest to Science Education" (Settelmaier, 2009) I argued that Haynes presented us with a paradox: her suggestion that the strength of the consistency and of the consequentialist perspectives is to provide an impartial and distanced form of cognitive accountability implying that in some situations these 'ethics' are the better options to choose. At the same time Haynes contends that this narrow focus on the cognitive realm is also its limiting factor: Kohlberg's framework she suggests, has failed because of its lack of empathy. This is why the world needed an ethic of care: an ethic that promotes connection and responsibility. Haynes is adamant that neither consistency, consequences, nor care, taken individually, provide an adequate foundation for ethical decisions: only jointly do they constitute the base for ethical decision-making (p. 26). Haynes argues further that neither type of ethic is superior to the others – they are all necessary components of a dialogical and relational process of moral

growth (p. 25). Thus she concludes, for moral growth to occur and for maturity to develop it takes the form of an 'evolving spiral' in which there is no prior value nor an end point (Haynes, 1998).

Ethical dilemma story pedagogy research – an overview

I have been engaged in the area of research into ethics in science classrooms and religion in science for about 15 years. Initially much of this empirical research focused on the usefulness of ethical dilemma stories as a valuable tool for science educators to address values in their own classrooms. Eventually the focus of the research shifted from the efficacy of ethical dilemma stories to pedagogical and philosophical aspects of values learning. Several research projects helped produce a body of knowledge that has yielded promising results and feedback from practising teachers and students (e.g., Settelmaier, 2009; Settelmaier, Taylor & Hill, 2010). My current research is still loosely connected to my original doctoral research which I briefly summarise below. Much of my subsequent research has been conducted in collaboration with Associate Professor Peter Taylor as a co-investigator expanding the horizons of the original project.

Doctoral research (1999-2003)

My first contact with ethical dilemma stories occurred when I was a team member of a curriculum development team hired by the Austrian Youth Red Cross to develop user-friendly curriculum materials that would allow teachers from all subject areas to address the requirement of the new national Austrian Curriculum which was published in 1997. We conducted detailed evaluations at the time and found that ethical dilemma stories were highly effective in engaging students in ethical- and values-learning. After migrating to Australia I chose to investigate how ethical story pedagogy could be integrated successfully into science education – my own area of subject specialization and interest. My study was an in-depth interpretive study of two Austrian science teachers and their classes – Year 9 and 10 respectively. For this inquiry I engaged in a field-based inquiry supported by a philosophical investigation exploring the vast field of moral philosophy. I discovered soon enough that the study of moral philosophers did not prove helpful for my designated task which was to find a suitable philosophy that would support the teaching of and learning with ethical dilemma stories. I moved on to the developmental psychologists who had investigated how children's morality develops – here I found promising



ideas based on constructivist philosophy in particular the works of Piaget and Kohlberg the latter suggesting an ethic of consistency or fairness. Feminist philosophy influenced Carol Gilligan and her ethic of care and it offered an attractive alternative or rather addition to Kohlberg's philosophy. It was not until I discovered Haynes's integral philosophical approach to ethics teaching and learning that I could draw on a solid philosophical framework helping me interpret my research data obtained through classroom observations, teacher- and student interviews and video analysis. Analysing particularly student discussions and argumentation, I found that all three types of ethics suggested by Haynes were actually used by students and teachers. Yet I was unable to draw a clear line between genders as Gilligan was implying – I studied several young male participants whose arguments could be placed within an ethic of care and several female participants whose arguments seemed framed by an ethic of consistency. Some students and teachers employed an ethic of consequences. Many students were using all three at different stages of the argumentation. My doctoral thesis was published as a book - for a more detailed description of the research and its outcomes see Settelaar (2009). In the following section of the paper I would like to provide a brief overview of our ongoing research into ethical dilemma story pedagogy within the field of socially responsible science education and education for sustainability.

The Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project – “Socially Responsible Science”

During 2007 and 2008 we received funding from the Australian Government in the form of a national teaching and learning grant. The project was based on my doctoral work and allowed us to work closely with 22 science teachers from metropolitan Perth all of whom teaching in low-socioeconomic areas with a variety of social and cultural problems. During the project we acted as professional development consultants and mentors. We introduced the teachers to ethical dilemma story pedagogy and the underpinning philosophical ideas. One aim of the project was for the teachers to develop their own dilemma stories that would fit within their curriculum and their local social and cultural contexts. These stories would then be published on a website and thus become available for teachers all over the world. The results of this

project can be found on www.dilemmas.net.au. We conducted research throughout the project and particularly during the implementation and evaluation phase i.e. when the teachers were trialling their own stories in their classrooms. We developed the Values Learning Environment Survey (VLES) which was validated during this project and is available from the above website. One interesting aspect of the analysis of the VLES was that it allowed us to investigate the depth of student engagement with the moral dilemma in the story. Students who had been engaged/disengaged with the ethical dilemma could be engaged in individual interviews which provided insights into student thinking and argumentation. More details on the results of this study have been published, e.g., in Settelmaier, Taylor and Hill (2010). Our most recent project was a three-year longitudinal study funded by the Australian Research Council (ARC). Its purpose was to inquire into the effects of repeated exposure to dilemma story pedagogy within the context of education for sustainability. In the following section examples have been drawn from previous and ongoing research. Pseudonyms have been used for schools and teachers.

“Sustainable Sustainability” - A three year longitudinal research project funded by the Australian Research Council (ARC)

This ARC research project was conducted between 2009 and 2011 at four schools in Western Australia, using both, an ethnographic, in-depth qualitative approach and the Values Learning Environment Survey (VLES) (Settelmaier, Taylor & Hill, 2010). In this project we focused on the integration of sustainability education into the mainstream science curriculum. We were interested to see how teachers at different schools, catering to different age groups and ability levels adapted ethical dilemma story pedagogy. During professional development intensives we introduced teachers to the dilemma teaching approach described by Gschweidl, Mattner-Begusch, Neumayr, and Schwetz (1998) and to basic philosophical assumptions underpinning the approach. During an intensive professional development seminar teachers learned how to write new or adapt existing stories suitable for ethical dilemma pedagogy. Teachers were introduced to the teaching of dilemma story lessons. Consequently teachers creatively developed or adapted existing stories in order to integrate values learning and sustainability issues into their curricula. For us, it was exciting to see how different teachers adapted our approach to dilemma teaching to the



needs and to the needs and ages of their students ranging from 6 year olds to 17 year olds. In the following section, I provide a brief overview of some of the aspects of the larger project by focusing on individual schools in turn. In line with research ethics requirements pseudonyms have been used for schools and teachers unless the teachers were co-authors in subsequent publications.

Peppermint Heights

Peppermint Heights is a government primary school in Perth's south with an explicit focus on sustainability. It is one of the participating schools in the Australian Sustainable Schools Initiative (ASSI). The school was built around sustainability principles: there is an organic vegetable garden, solar energy panels, recycling of waste and waste-water. Teachers are expected to include teaching for sustainability in their curricula. One could argue that an ethic of care for the environment is very strongly represented in the school's philosophy and set up. Three teachers at the school committed to participating in our project: Annie and Alma decided not to use any of the existing dilemma stories available on the www.dilemma.net.au website. Their argument was that these stories were written for adolescents whilst their students were between 9 and 11 years old in Year 4 and 5 respectively. They decided to adapt existing chapters from a book written for that age group. The book, "The Valley of Gold" by Jackie French (2003) describes the environmental and social changes in a particular valley in New South Wales since early Aboriginal settlement to modern times. Alma and Annie chose two chapters and adapted them as ethical dilemma stories. The teachers adopted ethical dilemma story pedagogy whereby the story was interrupted by dilemma questions with personal reflection and discussions taking place at appropriate times during the ethical dilemma lesson. The approach of adaptation of existing materials worked well for these teachers particularly since they had discovered that ethical dilemma stories lent themselves to the teaching of 'persuasive texts' - a genre of text now one of the foci of the Australian, national, standardised testing program - NAPLAN. Both teachers reported positive experiences with the effectiveness of ethical dilemma stories to engage primary school age students in dilemma thinking. A PowerPoint presentation titled "Dilemma stories – putting persuasive writing into context" written by

one of the teachers is available from the school website (http://www.harmonyps.org.au/articles.php?req=read&article_id=155). This PowerPoint was presented at a sustainability education conference at Curtin University held in June 2010 where our project was showcased. The third teacher, Emma, chose yet another adaptation of ethical dilemma story pedagogy. She teaches young children in a combined class of Year 1 and 2. Her students are between 5 and 7 years old. Emma is of indigenous Australian origin and integrates traditional indigenous knowledge in her teaching. Storytelling comes easy to her since this is how she approaches teaching on a regular basis. She reportedly allowed the dilemma stories to ‘unfold’ guided by the students’ questions rather than using the teacher’s preconceived questions. She started the story by introducing the students to Australian ‘bushtucker’ (= bush food). Her PowerPoint titled “Save our bush food” presented at the abovementioned Sustainability Showcase Conference is also available from the school website (http://www.harmonyps.org.au/articles.php?req=read&article_id=155) as a YouTube file. Detailed results of this aspect of the ARC project form part of a doctoral thesis which is still ongoing.

Hardbridge College

Hardbridge College is a community high school in Perth’s east offering secondary education up to Year 10. The high proportion of indigenous Australian students requires teachers to make adaptations to the mainstream curriculum and make it more culturally relevant and community based. Low literacy and numeracy levels plus many problems common in low socio-economic areas tend to affect student learning. MeiLing is an energetic and dedicated science and mathematics teacher who has good rapport with students and who is always interested in finding ways to engage her students. She wrote, taught and evaluated two dilemma stories: “The Prime Minister” dilemma raises the question if some time in the future money should be spent on fixing existing environmental problems rather than be spent on providing half of Australia’s population with an escape to outer space and to a new life. Initial analysis of survey data, observations and interviews indicate that Mei Ling’s students were involved in dilemma thinking and appreciated the opportunity to voice an opinion. MeiLing’s second dilemma story was titled “Akiki’s Dilemma” and focused on a boy whose father works in the mining industry in Western



Australia's north – a very relevant topic in present day Western Australia. The community is confronted with the decision as to whether a mining project that is likely to damage the delicate environment is to go ahead. The dilemma question was, “what is more important to the community – the environment or improved job prospects?” It was interesting to note that whilst many of the interviewed students were in favour of protecting the environment, the father's job prospects were ultimately regarded as more important. This result is not that surprising given that many of the students are constantly faced with prospects of unemployment and poverty on a daily basis. Both dilemma stories written by MeiLing are available on the www.dilemmas.net.au website. In classroom observations of student discussions we were able to identify a strong ethic of care based on strong family relationships and community networks, whilst some students seemed more concerned about the consequences of the decisions on families. For more details on the results of this part of the project, see our forthcoming chapter Taylor, Taylor and Chow (in press) to be published by Springer in Mansour and Wegerif (Eds.) “Science Education for Diversity” later this year.

St John's College

St John's College is a denominational school in Perth's more affluent north. In this school, we failed to recruit any of the science teachers for our project since they were too busy covering content. We were however offered the treat of working with two highly motivated and a highly experienced teachers of two different learning areas: Ray who is Head of Mathematics, and his counterpart, Tim, who is Head of English. These two teachers decided to come on board with a view to teach education for sustainability by integrating across mathematics and English. They work with gifted and talented Year 9 students in a high-tech environment and with supportive timetabling. One might ask, how can mathematics and English be integrated to focus on sustainability issues? Ray and Tim, like Anne and Alma, opted for adapting an existing story instead of writing their own. They started off by using a picture book titled “The Window” by Jeannie Baker to address the requirements of the English curriculum and in preparation for the National testing program NAPLAN. As with Annie and Alma, Tim had discovered that ethical dilemma stories were useful to teach

‘persuasive text’ in English - in his case to Year 9 students. The Window presents the life story of a boy through snapshots taken every two years out of the same window illustrating the environmental impact of urbanisation as seen through the eyes of a boy and then the man. The dilemma question raised by the book is: “since we all need to live somewhere - how can we minimise the environmental impacts of urban sprawl?” Details on the book and the story can be found on the website www.dilemmas.net.au.

It was interesting to see how Time and Ray addressed their respective disciplines in relation to the book and to sustainability. Ray discussed issues such as the Fibonacci sequence, the Golden Ratio, linear and exponential growth, perspective, hyperbole from a mathematics point of view whilst Tim discussed perspective, hyperbole and exaggeration from an English point of view. Students were required to write a report on their learning using their mathematics insights to support their dilemma argumentation for English.

After completing the picture book dilemma, these two enterprising teachers ventured into yet another uncharted territory of curriculum integration: they used “The Man from Snowy River”, a famous Australian ballad written by Banjo Patterson in the 19th Century as their second dilemma story. This ballad has at its core an environmental and ethical dilemma – a famous and expensive horse runs off and joins a herd of brumbies in Victoria’s Snowy Mountains. Brumbies to this day pose an environmental problem due to their impact on the natural environment. Now, like back in the 1860s, the question of culling the wild horses is as current as ever – raising questions about the value of life versus the value of the environment.

Prolonged engagement in the research context lasted for about a year and included VLES surveys followed by interviews with individual students and extensive classroom observations. This enabled us to conclude that many students appreciated the mental stimulation and the engagement with ethics through literature and mathematics. Some students reported that they had already held strong views in relation to the environment prior to this learning experience which had only become more pronounced through the dilemma lessons. Some students however, reported they prefer pure mathematics and pure English over curriculum integration. They admitted to being unable to see the point in mixing the two. Several students used argumentation in



line with all three ethics - care, consistency and consequences. For more details of results of this aspect of the larger research project, please, see our forthcoming paper Taylor, Taylor, Williams and Manea (in press) which was presented at the recent International Conference on Science, Mathematics and Technology Education (SMTE) in Muscat, Oman.

Conclusion

Education for sustainability requires a solid philosophical basis that allows for multiple ethical viewpoints held together in a dialectical tension. In our research on ethical dilemma story pedagogy particularly within the context of education for sustainability I have found Haynes' integral philosophical model to provide a most useful theoretical framework for a value-added science education and education for sustainability for the 21st Century. It successfully marries Gilligan's, Kohlberg's, and Consequentialist viewpoints and thus allows for multiple ethical perspectives to be integrated. The use of Haynes' 'Borromean Knot of Ethics' in my research has offered a valuable dialectical tool for investigating student engagement with ethical dilemmas.. In our research we found that students and teachers were drawing on all three types of ethics – a clear demarcation along gender-boundaries as suggested by Gilligan was not evident. Summarising, Haynes' philosophical view paired with learning theories such as critical constructivism seems to provide a philosophical framework allowing teachers to support students to develop into responsible, autonomous, democratic citizens, who are able to: (1) practise an ethic of consistency, (2) evaluate the consequences of their actions, and (3) apply empathy and care in their lives. All of these are character strengths are sought after in decision-makers of the future – people on whose decisions our survival and the sustainability of the world's resources will depend. Our ongoing research on education for sustainability indicates that students from different age groups and different socio-economic backgrounds have found learning through ethical dilemma stories engaging and useful for raising interest in sustainability issues.

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