

- DeLeuze, G. & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. Minneapolis: University of Minnesota Press.
- Durie, R. (2000). *Time and the instant*. Manchester, England: Clinamen Press.
- Hoeg, P. (1994). *Borderliners*. New York: Dell Publishing.
- Husserl, E. (1991). *On the phenomenology of the consciousness of internal time* (B. Brough, Trans.). Boston: Kluwer Academic Publications.
- Kohak, E. (1984). *The embers and the stars*. Chicago: University of Chicago Press.
- Louv, R. (2005). *Last child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill, N.C.: Algonquin Books of Chapel Hill.
- Lynch, K. (1972). *What time is this place?* Cambridge, MA: M.I.T. Press.
- Macy, J. R. & Brown, M. J. (1998). *Coming back to life: Practices to reconnect our lives*. Gabriola Island, BC: New Society Publishers.
- McHarg, I. L. (1992). *Design with nature*. New York: John Wiley.
- Merleau-Ponty, M. (2003). *Nature: Course notes from the college of France* (R. Vallier, Trans.). Evanston, IL: Northwestern University Press.
- Ouspensky, P. D. (1997). *A new model of the universe*. England: Dover Publications.
- Ricoeur, P. (1983, 1984, 1985). *Time and narrative*, v. 1-3. (K. McLaughlin & D. Pellauer, Trans.). Chicago, IL: University of Chicago Press.
- Rifkin, J. (1989). *Time wars: The primary conflict in human history*. New York: Simon & Schuster.
- Rossatto, C. A. (2005). *Engaging Paulo Freire's pedagogy of possibility*. Lanham, UK: Rowman & Littlefield.
- Schafer, R. M. (1994). *The soundscape: Our sonic environment and the tuning of the world*. Rochester, VT: Destiny Books.
- Serres, M. & Latour, B. (1995). *Conversations on science, culture and time* (R. Lapidus, Trans.). Ann Arbor, MI: University of Michigan Press.
- Stark, K. (2006). *Yogic seeds, sprouting bodies: Moving, teaching, learning, knowing*. Unpublished MES major paper, Faculty of Environmental Studies, York University, Toronto, Ontario.
- Torreiter, H. (2005). *Farms and schools: Cultivating communities*. Unpublished MES major paper, Faculty of Environmental Studies, York University, Toronto, Ontario.
- Waslander, E. (2006). *From grass to gardens: Creating gardens and supporting youth voices through popular experiential education curriculum*. Unpublished MES major paper, Faculty of Environmental Studies, York University, Toronto, Ontario.
- Wein, C. A. (1996). Time, work, and developmentally appropriate practice. *Early Childhood Research Quarterly*, 11(3), 377-403.
- Wein, C. A. & Kirby-Smith, S. (1998). Untiming the curriculum: A case study of removing clocks from the program. *Young Children*, 53(5), 8-13.
- Zerubavel, E. (1981). *Hidden rhythms: Schedules and calendars in social life*. Chicago: University of Chicago Press.
- Zerubavel, E. (1985). *The seven day circle*. New York: The Free Press.

Virtues, Teacher Professional Expertise, and Socioscientific Issues

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Abstract

This article develops the notion that virtues can be utilized as a means of understanding the professional expertise that science teachers demonstrate when they deal with socioscientific issues. Socioscientific issues are those contentious issues that connect science to the society in which it operates—environmental issues being a prime example. We begin by accepting that both the cognitive and the affective facets of teaching represent a professional expertise that can be discussed using a moral language of virtues. These virtues are trust, care, courage, honesty, practical wisdom, and fairness. In developing our notion, we draw on the work of Zeidler, Sadler, Simmons, and Howes, who have argued that an exploration of four pedagogical elements (the nature of science, classroom discourse, cultural issues, and case-based issues) constitutes a research-based model for addressing moral education in the context of science education. It is our purpose to investigate the ecological validity of using virtues as descriptors of teacher professional expertise within each of these issues.

Résumé

Cet article explique la notion que la vertu peut être un moyen de comprendre l'expertise professionnelle que les enseignants en science démontrent lorsqu'ils jonglent avec les enjeux socioscientifiques. Les enjeux socioscientifiques sont ces controverses qui lient la science à la société dans laquelle elle fonctionne – les enjeux de l'environnement en sont un exemple primordial. Nous commençons par accepter que les facettes et affectives et cognitives de l'enseignement représentent une expertise professionnelle qui peut être examinée à l'aide d'un langage éthique de la vertu. Ces vertus sont la confiance, l'attention, le courage, l'honnêteté, la sagesse pratique et l'équité. En expliquant notre concept, nous nous appuyons sur le travail de Zeidler, Sadler, Simmons et Howes, qui a soutenu qu'une étude de quatre éléments pédagogiques (la nature de la science, la discussion en classe, les enjeux culturels et les problèmes d'étude de cas) constitue un modèle basé sur la recherche pour aborder l'éducation morale dans un contexte d'éducation scientifique. Notre but est d'étudier la validité écologique de l'utilisation de la vertu à titre de descripteur de l'expertise professionnelle de l'enseignant dans chacun de ces enjeux.

Keywords: virtues; socioscientific issues; teacher professional expertise

Introduction

In many education jurisdictions, environmental education is infused into the science curriculum. This infusion requires students to not only understand the science behind environmental issues, but also equip them to “deal with the impacts of science on society, and this requirement brings in issues that relate to human values” (Ontario Ministry of Education, 1999, p. 3). In order to accept this challenge, there is an ongoing conversation within science education as to how best provide students with “meaningful experiences [around] controversial, socially relevant issues” such as the environment (Sadler, Amirshokohi, Kazempour, & Allspaw, 2006, p. 353). It is the development of a professional expertise in response to this challenge that is the focus of this article.

In their teaching, secondary teachers develop a professional expertise that includes the construction of a common identity as subject teachers, the negotiation of meaningful knowledge, and engagement in the task of improving teaching and learning within classrooms and within schools (Avery & Carlsen, 2001; Grossman, Wineburg, & Woolworth, 2001; Helms, 1998; Little, 2003; Wildy & Wallace, 2004). This expertise can be described using a moral language of virtues: trust, care, courage, honesty, practical wisdom, and fairness (Socokett, 1993). In seeking to understand the expertise that teachers bring to their teaching, and the importance of the individual teacher in the task of teaching socioscientific issues, we believe that an understanding of these virtues is central.

In this article we develop the notion that virtues can be utilized as descriptors of professional expertise in the context of socioscientific issues. Further, we demonstrate the ecological validity of our notion by discussing it in relation to the empirical framework for functional scientific literacy described by Zeidler, Sadler, Simmons, and Howes (2005). This framework involves the four elements of nature of science issues, discourse issues, cultural issues, and case-based issues.

Theoretical Framework

Socioscientific issues can be defined as “societal dilemmas with conceptual, procedural, or technological links to science” (Sadler & Zeidler, 2004, p. 5). This definition is not to argue that science and society are independent human constructs, for science is inseparable from the society in which it develops. As dilemmas, socioscientific issues are generally contentious, given the number of perspectives from which they can be perceived, the lack of definitive answers to the questions which they pose, and their frequent moral considerations (Hodson, 2003; Kolstø et al., 2006; Sadler, 2004; Sadler & Zeidler, 2004). Further, the ability to carefully consider and negotiate

socioscientific issues is an increasingly important goal of science education (American Association for the Advancement of Science, 1989; Organisation for Economic Co-operation and Development, 2001; Sadler, 2004; Sadler et al., 2006). Environmental issues, in the widest sense of the phrase, can be described as socioscientific issues.

In the consideration of socioscientific issues, three moral philosophies are applicable: deontology, consequentialism, and care-based morality (Sadler & Zeidler, 2004). Deontology is founded on moral rules or principles that guide an individual's decision-making and behaviour. This means that "individuals employing deontological reasoning solve moral problems by considering principles relevant to the act of the decision itself irrespective of the potential consequences" (Sadler & Zeidler, 2004, p. 6). Consequentialism is predicated on the perceived outcomes of any decision, with a decision that produces the greatest positive outcome becoming the "most morally correct option" (Sadler & Zeidler, 2004, p. 7). Care-based morality rejects the notion that there is a single method for resolving moral issues. Rather than principles or calculations, this perspective stresses relationships in which "emotions such as sympathy and empathy contribute significantly to decisions and actions" (Sadler & Zeidler, 2004, p. 7).

Whichever philosophical perspective is chosen there remains the important point that the individual teacher(s) involved in a situation must recognize the existence of a moral dimension (Kolstø, 2001; Kolstø et al., 2006; Sadler, 2004; Sadler & Zeidler, 2004). This is a clear and present challenge for teachers, as it has been suggested that the "moral aspects of socioscientific issues are primary determinants of student decision-making" (Sadler & Zeidler, 2004, p. 22). Failure to attend to the moral and ethical considerations of socioscientific issues that are important to students, such as the environment, may act to degrade the efficacy of what is taught and "encourage the tendency for students to isolate school science from their everyday experiences" (Sadler & Zeidler, 2004, p. 22). Individual teachers, it would seem, must also construe socioscientific issues as moral issues, especially if they are acting as the "final arbiters of morality" (Sadler & Zeidler, 2004, p. 7). This critical role of the teacher as a "final arbiter of morality" raises three important considerations for science teachers dealing with socioscientific issues. These are the need for specificity in the content that students are taught, the need for topics to possess relevance for students, and the need to present pedagogically appropriate knowledge to students (Kolstø, 2001). These considerations encompass the cognitive and affective domains of teaching and teacher professional expertise. As such, they lead us to consider virtues as a potential descriptor for that expertise.

The reason for considering the utility of virtues as descriptors of professional expertise is that professional virtues are "those acquired moral qualities that are embedded in the social practice of teaching and that are necessary to the particular professional task" (Sockett, 1993, p. 62). Specific

research into socioscientific issues and teachers' perceptions of the place of values and ethics in science found that 19 of 20 science teachers "acknowledged a significant role for values and ethics in science" (Sadler et al., 2006, p. 360). Allchin (1999) states that a disregard for the importance of ethics in science education is to deny a richer understanding of the nature of science: "a deeper understanding of science, values and objectivity ... supports a mandate for discussing values in the classroom" (p. 9). Socioscientific issues, it has been claimed, "focuses specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles of virtues that encompass their own lives, as well as the physical and social world around them" (Zeidler et al., 2005, p. 360). This link between virtues and practice is important as it commits a professional teacher to both acquire and live out certain beliefs (Lovat, Schofield, Morrison, & O'Neill, 2002). In the contentious field of socioscientific issues education, this linkage is fundamental as a dissonance between rhetoric and action is open to the charge of hypocrisy.

There is a problem, however, in using virtues in a post-industrial society. The problem is that moral qualities may no longer be seen as "embedded in the social practice" (Sockett, 1993, p. 62), but may have already been decontextualized and supplanted by government mandate. This is the point that Wells (1998) makes:

Classical virtues had always been thought about in relation to the community in which a person lived. To act justly was not an internal attitude, but the practice of what was upright in a context where that moral virtue had been put to the test. When we come into the modern period, and as communities begin to disappear, the virtues come to stand alone, out of the social context in which they had formerly been understood. (p. 15)

While the language of virtues can be traced at least back to Aristotle (Trans. 1962), the process of decontextualizing virtues began during the Age of Enlightenment in the 18th and 19th centuries. At this time, they began to lose their pre-eminent role in the conduct of the civil society, to be replaced by rules, and finally, by government regulation:

When the virtues were thus privatised, when they were disengaged from private life, that life had to be governed, not by morality, but by social rules that became etiquette. It was these rules that replaced the virtues, and these rules have now been replaced by government regulation and by litigation. (Wells, 1998, p. 15)

Sockett (1993) acknowledges the replacement of the virtues by mandate, stating that "in loco parentis has been replaced by due process" (p. 22). This does not mean, however, that virtues have lost their potential as descriptors of professional expertise. For education, and specifically teaching, is a moral undertaking that includes the moral and ethical growth of students (Loving, Lowy, & Martin, 2003).

Kidder (1994), assuming a deontological perspective, describes eight universal values that he believes are essential for the development of moral conditions in the 21st century. These values are love, truthfulness, fairness, freedom, unity, tolerance, responsibility, and respect for life. Newell and Rimes (2002) state that these values—or virtues—“apply regardless of the religious or secular tradition in a school” (p. 94). Lovat (1994, 1995) argues that the biomedical ethics of autonomy, justice, non-maleficence and beneficence have a role in shaping the practice of teachers. These authoritative ethics can only be effectively communicated to students if the teacher demonstrates “consistency of theory and practice, ideas and action” (Lovat et al., 2002, p. 129). For the analysis of the work of the teachers in our study, we shall utilize the virtues of honesty, courage, care, fairness, and practical wisdom proposed by Sockett (1993). While we acknowledge the importance of both human-centred and life-centred ethics (Mortari, 2004), we believe that a language of virtues offers a useful way of examining teachers’ professional expertise in the context of socioscientific issues. This language, therefore, needs to be more fully explicated in the context of this article.

The Virtues

Honesty is the virtue that serves as the basis on which social life is constructed (Sockett, 1993). This virtue contains several components, each of which is important for the professional teacher to demonstrate. The first of these components is an understanding of the difference between fact and fiction, the ability to distinguish the real from the imaginary, and a willingness to teach this understanding to students. This understanding can be difficult to acquire and teach, as it covers a range of potential areas in which the distinction between fact and fiction, and real and imaginary, can become blurred for a variety of factors. These include a neglect of those facts that may be considered, rightly or wrongly, to be inconsequential or unpalatable to the teacher. It may also include a failure to explore alternative perspectives on the topic that is being taught, although this would depend on the developmental stage of the student. The personal bias of a teacher may also come into play, as well as a deliberate or unintentional misrepresentation of the truth. These factors are of particular relevance in relation to complex socioscientific issues, in which teachers express an ill-preparedness and lack of resources in dealing with controversies (Levinson, 2004; Sadler et al., 2006).

Second, teachers need to display a concern for the truth, as opposed to falsity in any situation, and for how the truth is to be sought after. It is not enough to simply question, it is a case of which question will most decisively facilitate the search for the truth in the content (Sockett, 1993). Obviously, there will be times when there is no position that could be described as the truth, and in this situation it is important to rigorously examine what information is

known. In such a case, questions should be deployed that vigorously examine different positions, with the express aim of facing hard choices and making decisions about what is considered truthful. Facilitation of opportunities for presenting and challenging arguments allows students to consider the “quality of claims, warrants, evidence, and assumptions among competing positions” (Zeidler et al., 2005, p. 365). The provision of opportunities that allow for argumentation around socioscientific issues are an important aim of science education (Aikenhead, 2000; Driver, Newton, & Osborne, 2000).

However, attempts to support this notion of what is true are difficult in an increasingly pluralistic society. Students, therefore, need to be taught an “ethic of belief” (Sockett, 1993, p. 67) that is based on evidence, if they are to face the moral complexity of the world as autonomous moral agents. In socioscientific decision making, research suggests that individuals give primacy to values, ethics, societal concerns, and persuasiveness over scientific evidence (Bell & Lederman, 2003; Sadler, Chambers, & Zeidler, 2004). From an ethical perspective, the evidence presented in classrooms needs to fulfill two criteria. First, the evidence needs to be factually true and morally acceptable. Second, the evidence should help the student develop the connection between belief and truth; that is, the student should learn to believe in what is true, or in what has good evidence. The aim of teaching such an ethic based on evidence is to permit students to function as citizens in “a complex democratic society that is riddled with hard choices demanding attention to evidence” (Sockett, 1993, p. 67). The development of such reasoning skills is central for the promotion of socioscientific issues in science education (Zeidler et al., 2005). The principle of autonomy comes into this aim, as it is a principle that “assumes that the individual is responsible for, and should therefore determine the direction of, his or her own life” (Lovat et al., 2002, p. 128). As Aikenhead (1990) states, “to be intellectually independent is to assess, on one’s own, the soundness of the justification proposed for a knowledge claim” (p. 132). This link between autonomy and authentic knowing has been widely discussed in the literature over the past four decades (Lovat et al., 2002).

In teaching such an “ethic of belief” and developing the autonomy of the student, it is not simply a case of presenting information to a child; the teacher must also model and live such an ethic in all his or her teaching. Lovat et al. (2002) state that there is “a particularly strong responsibility on a profession charged with the teaching of morality to be seen as practising it as well” (p. 128).

Trust is another component of honesty. Trust is totally dependent on the absence of deceit if it is to be regarded as authentic (Sockett, 1993). Trust can be lost through a failure to state the truth, for whatever reason, or through the misuse of authority to gain control. Professional teachers who care about the truth will not misrepresent the status of knowledge; they will recognize that there are other ways of questioning knowledge, and pass this on to their

students. To do this, however, often requires the second virtue of courage.

Courage as a moral quality can be defined as “deliberate, practical reasoning in circumstances of difficulty, turbulence or trouble” (Sockett, 1993, p. 71). Courage, as such, can exhibit a variety of characteristics (Sockett, 1993). It may include a long-term commitment to ideals that are closely held. Hence, it is not related solely to fear or to physical action. Finally, courage will be evident in many different social and institutional practices. Within education, courage is needed in the pursuit of the truth in—at times—difficult circumstances. Learners, when operating in a difficult context, often need to be encouraged. Such a context may be the learning of new material, learning a new skill, or learning to concentrate to resolve a difficulty. To encourage a student is a moral act, with a purpose to “get children to learn whatever is to be learned and also to summon up their will in those situations of difficulty” (Sockett, 1993, p. 74). Teachers are also required to demonstrate courage in the out-of-class place described by Clandinin and Connelly (1995). Teachers are often confronted with changes imposed by those who desire to implement “new and imaginative educational reforms”; in these confrontations, teachers have the ability to rise to the challenge and take charge of their “moral professional landscape” or to be subversive and tell “cover stories” that agree with what the reformers in the conduit want to hear (Clandinin & Connelly, 1995, pp. 162-163). Which path is taken depends, in large part, on the congruency of the reforms with the teachers’ desire to change (Hargreaves, 1994).

The third virtue that Sockett describes is care, a notion that has become a “staple of educational scholarship” (Schultz, 1998, p. 373). From a care perspective, to ignore the import of emotion, politics, and societal influences in scientific decision making is “not only impossible, but dangerous” (Zeidler et al., 2005, p. 368). Noddings, in particular, has made several contributions to the discussion of this virtue. There are three major tenets to Noddings’ conceptualization of care. The first of these is that each human being is unique. Second, building on this individual uniqueness, there is a unique relation between two people (the carer and the cared-for) in which each maintains the otherness of the other (Noddings, 1992). Third, in caring, we “treat each situation and each cared-for (person) as unique” (Schultz, 1998, p. 375). In a caring relation, which is a dynamic, but equal relation, there is no judgement of the other person, and the carer has the responsibility to respond to the cared-for “in a way that furthers the others’ purpose or project” (Noddings, 1992, p. 16). Caring requires action and the development of an attitude by those who are cared-for to become, in turn, carers (Schultz, 1998). Finally, Noddings argues that caring has a naturalistic base; others such as Schultz disagree, seeing it as a social practice that can be learned.

In relating caring to communities in general and schools in particular, there are a number of features that characterize an authentic community (Noddings, 1996). Authentic communities avoid “tendencies towards

parochialism, conformity, exclusion, distrust (or hatred) of outsiders and coercion” (Noddings, 1996, pp. 258). Authentic communities also offer individuals the opportunity to “be part of something significant” (p. 260). As such, communities offer opportunities for student development when they open “up the horizons from within which science and self are understood and contribute to the evolution of both” (Kozoll & Osborne, 2004, p. 170). This conceptualization of caring is in contrast to ethics, which are based on principles, which, while not unimportant, are seen to be fundamentally masculine in nature and treat individuals as comparable and classifiable (Noddings, 1989). Critics of Noddings believe that caring, without an ethic, such as justice, to support it, is unable to provide protection against oppression or make a commitment “to those who cannot be cared for directly” (Schultz, 1998, p. 373). Justice is thus the fourth virtue discussed by Sockett (1993). This leads to a need for the examination of other virtues that impinge upon Noddings’ conceptualization of caring, non-maleficence and beneficence.

Non-maleficence and beneficence are two biomedical ethics that Lovat et al. (2002) believe have a powerful role to play in the guidance of teacher practice. Non-maleficence reflects a requirement that the conduct of a professional does not harm or injure another person. For teachers, this includes not just the physical wellbeing of students, but also the intellectual health of the student. This being the case, it is possible that teachers are in a position to cause “intellectual harm” through poor pedagogy, poor subject knowledge, and poor, or unfair, assessment (Lovat et al., 2002, p. 129). Beneficence is a general ethical principle under which the ethical person has a “duty to engage in conduct that is aimed at the good and wellbeing of others” (Lovat et al., 2002, p. 129). For teachers, this involves a duty to develop both the physical and intellectual wellbeing of those students in their care (Peters, 1972).

The fourth virtue described by Sockett (1993) is fairness. This virtue, also called justice, is, along with truth, described as being “uncompromising” (p. 81). The essence of fairness is found in Aristotle’s axiom that justice consists of treating equals equally and unequals unequally—but in proportion to their relative differences (Sockett, 1993). Justice also gives a clear expectation of what a society believes is appropriate for the relationships between members of that society (Lovat et al., 2002). There are also two types of justice to consider (Sockett, 1993). The first is distributive justice, where consideration is given to the distribution of benefits; the second is retributive justice, where the consideration is to right a wrong, or punish a law-breaker. Relating these notions to teaching, there are three issues that need to be addressed: the distribution of time and attention to students’ intellectual and social needs in a way that is fair to all within the class, the imposition of sanctions and discipline, and the monitoring of the deployment of teachers in a way that can be considered fair to both teachers and students, irrespective of their status (Lovat et al., 2002).

The fifth and final virtue is that of practical wisdom. Wisdom is described as a quality of reflectiveness and judgement that assists in answering the question “what to do and why?” In Sockett’s (1993) view, it includes subject knowledge or *episteme* (content), and pedagogical skills or *techne* and *phronesis* (method). The Ontario College of Teachers’ “Standards of Practice” (1999) express the same belief:

Professional knowledge is the foundation of teaching practice. Members of the Ontario College of Teachers know the curriculum, the subject matter, the student, and teaching practice. They know education-related legislation, methods of communication, and ways to teach in a changing world. (pp. 5-6)

The United States National Board of Professional Teaching Standards “Policy Position” (1989) makes a similar statement in the second of five core propositions:

National Board Certified teachers have a rich understanding of the subject(s) that they teach and appreciate how knowledge in their subject is created, organized, linked to other disciplines and applied to real world settings. While faithfully representing the collective wisdom of our culture and upholding the value of disciplinary knowledge, they also develop the critical and analytical capacities of their students. (p. 1)

In concluding this discussion on the dimension of professional expertise, we believe that it is hard to go past what Sockett (1993) writes concerning the moral imperatives of both teaching and learning:

... just as we have lost some of our moral sensibilities because we have stopped using a moral vocabulary, so we will lose much more if we ignore our world culture, its history, artefacts, conventions and styles; and settle for some empty hybrid like critical thinking. A teacher cannot understand many practical issues within teaching without being learned. (p. 86)

It is imperative that teachers cater to both the intellectual and moral growth of their students. Science teachers have a number of potential strategies for this development, among them the use of controversial socioscientific case studies (Simmons & Zeidler, 2003; Zeidler et al., 2005) and the development of a consensus through discourse (Kolstø, 2001). As the *Ontario Curriculum Grades 11 and 12 – Science* (Ontario Ministry of Education, 2000) succinctly states, “there is no single correct way to teach or learn” (p. 8).

Ecological Validity

Zeidler et al. (2005) argue that exploration of four pedagogical issues (nature of science, classroom discourse, cultural, and case-based) constitutes a research-based model for addressing moral education in the context of

science and environmental education. It is our purpose here to investigate the ecological validity of using virtues as descriptors of teacher professional learning within each of these issues.

Nature of Science Issues

There is evidence that students who possess naïve conceptions of science will “distort whatever data, evidence, or knowledge claims are available to them for the purpose of supporting a predetermined viewpoint” (Zeidler et al., 2005, p. 363). Thus an “ethic of belief” in science education needs to guide them “in the process of synthesizing and applying their understanding of the nature of science as they evaluate and make decisions regarding socioscientific issues” (Zeidler et al., 2005, p. 364). This is an important consideration when dealing with the science behind many current issues such as global warming and genetically modified foods. This teaching of an “ethic of belief” is important if an individual is to function autonomously in a difficult, complex society. Individual autonomy is crucial, as autonomy allows for the authentic knowing that is needed in such a society. The teaching of such an evidence-based ethic may potentially provide for the capacity for individuals to utilize their reasoning capacities when confronted by other forms of knowledge, “based on the merit of supporting evidence in everyday life” (Zeidler et al., 2005, p. 365). Such a capacity founded on evidence that is factually true, morally acceptable, and which assists the student to develop the connection between belief and truth, provides a firm foundation for the development of an individual’s autonomy (Lovat et al., 2002).

Discourse Issues

The use of classroom discourse as a strategy for investigating socioscientific issues has great potential value for the development of an “ethic of belief” and the virtues that are implied in it (Khishfe & Lederman, 2006; Zeidler et al., 2005). Discourse around the nature of science provides students with a context to develop capacities for dealing with dynamic situations (Driver, Newton, & Osborne, 2000). Explicit attention to discourse, whether or not it is integrated within regular science content, has been demonstrated to improve students’ understandings of the nature of science (Khishfe & Lederman, 2006). For teachers to engage with students in issues which are tentative, empirical, subjective, and creative requires a high level of practical wisdom and courage. Practical wisdom and courage may allow a teacher to develop strategies that both accurately represent their subject while concurrently dealing with the simultaneous pressures to cover content and attend to students’ “moral commitments, emotions and moral behaviour” (Zeidler et al., 2005, p. 366). However, the growth of practical wisdom should not be seen as the exclusive responsibility of an individual teacher.

Levinson (2004) suggests that, given the complexities of developing discourse within their classrooms, teachers may benefit from specific professional learning opportunities in argumentation and discourse.

Cultural Issues

Cultural issues impinge significantly on the classroom treatment of socioscientific issues, particularly given the diversity of student beliefs now found in classrooms. From a reliance on the primacy of moral principles, cultural issues are now seen to also include “care, emotion and contextual factors” (Zeidler et al., 2005, p. 367). This is an important change in emphasis, given the importance of emotions in considering socioscientific issues (Noddings, 1992). Further, it becomes imperative that students be given the opportunity to develop the use of both rationality and emotion in their responses to socioscientific issues (Zeidler et al., 2005). For teachers trained in the sciences, heavily reliant on logical-scientific knowledge, rather than narrative knowledge (Bruner, 1986), this may present challenges. It is our contention that the virtues are powerful descriptors of the forms of professional expertise that teachers may need if they are to “foster classroom environments that encourage the expression of diverse perspectives” (Zeidler et al., 2005, p. 369). In terms of teacher professional expertise, the two virtues which speak most clearly to the importance of cultural issues are those of care and fairness. Care because of the clear link between it and critical considerations of socioscientific issues (Noddings, 1992; Zeidler et al., 2005) and fairness due to the need for teachers to ensure that their classrooms are value-fair (Loving, Lowy, & Martin, 2003).

Case-Based Issues

Students will be confronted with myriad socioscientific issues during their lifetimes. Case-based issues seek to prepare students to deal with these issues by involving them in issues that “embrace both their intellect and their sense of character” (Zeidler et al., 2005, p. 369). A cursory examination of case-based issues and the various protocols developed for their use in classrooms highlights the foundational importance of the virtues (Keefer, 2003; Kolstø, 2000; Pedretti, 2003). Each protocol relies on students accessing, evaluating, and synthesizing information which then informs their decision. This decision must be justifiable and made available for evaluation and review. Virtues impinge at each stage of these protocols. For example, the accessing and evaluation of information requires honesty, truth, and an “ethic of belief.” Likewise, the presentation and justification of one’s work to peers requires a measure of courage in oneself and trust in the feedback received. In promoting the use of virtues within the classroom, teachers can provide an environment in which students can construct knowledge “that is at once personally

relevant and socially shared ... that may be in conflict with one's existing conceptions regarding socioscientific moral and ethical issues" (Zeidler et al., 2005, p. 371). Such an environment, we would submit, is highly educative.

Final Comments

We have proposed that teacher professional expertise in the area of socio-scientific issues can be described using a theoretically robust language of virtues. It is our contention that the virtues of trust, care, courage, honesty, practical wisdom, and fairness offer a language that describes the teacher professional expertise required of the empirical model for reasoning around socio-scientific issues developed by Zeidler et al. (2005). The four issues at the heart of this model (nature of science, classroom discourse, cultural, and case-based) require teachers, we believe, to both acquire and live out the virtues. Through the explicit incorporation of virtues into their teaching, teachers may emphasize the "epistemological foundations, moral and ethical development and emotional aspects of learning science" (Zeidler et al., 2005, p. 371). In these uncertain times, such an emphasis is imperative.

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Notes on Contributors

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References

- Aikenhead, G. (1990). Scientific/technological literacy, critical reasoning, and classroom practice. In S. P. Norris & L. M. Phillips (Eds.), *Foundations of literacy policy in Canada* (pp. 127-145). Calgary, AB: Detselig.
- Aikenhead, G. (2000). Renegotiating the nature of science. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving science education: The contribution of science* (pp. 245-264). Buckingham, UK: Open University Press.
- Allchin, D. (1999). Values in science: An educational perspective. *Science and Education*, 8(11), 417-436.
- American Association for the Advancement of Science. (1989). *Science for all Americans*. New York: Oxford University Press.
- Aristotle. (1962). *Nicomachean ethics* (M. Ostwald, Trans.). Indianapolis, IN: The Library of Liberal Arts.
- Avery, L. M. & Carlsen, W. S. (2001, April). *Knowledge, identity and teachers' multiple communities of practice*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.
- Bell, R. L. & Lederman, N. G. (2003). Understanding of the nature of science and decision making on science and technology based issues. *Science Education*, 87(3), 352-377.
- Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge, MA: Harvard University Press.
- Clandinin, D. J. & Connelly, F. M. (1995). *Teachers' professional knowledge landscapes*. New York: Teachers College Press.
- Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84(3), 287-312.
- Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record*, 103(6), 942-1012.
- Hargreaves, A. (1994). *Changing teachers, changing times: Teachers' work and culture in the post-modern world*. London: Cassell.
- Helms, J. V. (1998). Science—and me: Subject matter and identity in science teachers. *Journal of Research in Science Teaching*, 35(7), 811-834.
- Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education*, 25(6), 645-670.
- Keefer, M. W. (2003). Moral reasoning and case-based approaches to ethical instruction in science. In D. L. Zeidler (Ed.), *The role of moral reasoning and discourse on socioscientific issues in science education* (pp. 241-260). Dordrecht, The Netherlands: Kluwer.
- Khishfe, R. & Lederman, N. (2006). Teaching nature of science within a controversial topic: Integrated versus nonintegrated. *Journal of Research in Science Teaching*, 43(4), 395-418.

- Kidder, R. (1994). *Shared values for a troubled world: Conversations with men and women of conscience*. San Francisco, CA: Jossey-Bass.
- Kolstø, S. D. (2000). Consensus projects: Teaching science for citizenship. *International Journal of Science Education*, 22(6), 645-664.
- Kolstø, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, 85(3), 291-310.
- Kolstø, S. D., Bungum, B., Arnesen, E., Isnes, A., Kristensen, T., Mathiassen, K., et al. (2006). Science students' critical examination of scientific information related to socioscientific issues. *Science Education*, 90(4), 632-655.
- Kozoll, R. H. & Osborne M. D. (2004). Finding meaning in science: Lifeworld, identity, and self. *Science Education*, 88(2), 157-181.
- Levinson, R. (2004). Teaching bioethics in science: Crossing a bridge too far? *Canadian Journal of Science, Mathematics and Technological Education*, 4(3), 353-370.
- Little, J. W. (2003). Inside teacher community: Representations of classroom practice. *Teachers College Record*, 105(6), 913-945.
- Lovat, T. (1994). The implications of bioethics for teachers and teacher researchers. *British Educational Research Journal*, 20(2), 187-196.
- Lovat, T. (1995). Bioethics teaching and the researcher teacher: Considerations for teacher education. *Action in Teacher Education*, 16, 71-78.
- Lovat, T., Schofield, N., Morrison, K., & O'Neill, D. (2002). Research dimensions of values education: A Newcastle perspective. In S. Pascoe (Ed.), *Values in education: College year book, 2002* (pp. 125-139). Canberra, ACT: Australian College of Educators.
- Loving, C. C., Lowy, S. W., & Martin, C. (2003). Recognizing and solving ethical dilemmas in diverse science classrooms. In D. L. Zeidler (Ed.), *The role of moral reasoning and discourse on socioscientific issues in science education* (pp. 183-194). Dordrecht, The Netherlands: Kluwer.
- Mortari, L. (2004). Education to care. *Canadian Journal of Environmental Education*, 9, 109-122.
- Newell, C. & Rimes, J. (2002). Beyond pious platitudes: Values, spirituality and curriculum. In S. Pascoe (Ed.), *Values in education: College year book, 2002* (pp. 92-102). Canberra, ACT: Australian College of Educators.
- Noddings, N. (1989). *Women and evil*. Berkeley: University of California Press.
- Noddings, N. (1992). *The challenge to care in schools: An alternative approach to education*. New York: Teachers College Press.
- Noddings, N. (1996). On community. *Educational Theory*, 46(3), 245-267.
- Ontario College of Teachers. (1999). *Standards of practice for the teaching profession*. Retrieved 28 March, 2001, from http://www.oct.on.ca/english/professional_affairs/plf_final.htm
- Ontario Ministry of Education. (1999). *The Ontario Curriculum Grades 9 and 10 – Science*. Toronto, ON: Queen's Printer for Ontario.
- Ontario Ministry of Education. (2000). *The Ontario Curriculum Grades 11 and 12 – Science*. Toronto, ON: Queen's Printer for Ontario.
- Organisation for Economic Co-operation and Development. (2001). *Knowledge and skills for life: First results from PISA 2000*. Paris: Organisation for Economic Co-operation and Development.

- Pedretti, E. (2003). Teaching science, technology, society and environment (STSE) education. In D. L. Zeidler (Ed.), *The role of moral reasoning and discourse on socioscientific issues in science education* (pp. 219-240). Dordrecht, The Netherlands: Kluwer.
- Peters, R. (1972). *Ethics and education*. London: Allen & Unwin.
- Sadler, T. D. (2004). Moral sensitivity and its contribution to the resolution of socio-scientific issues. *Journal of Moral Education*, 33(3), 339-358.
- Sadler, T. D., Amirshokooi, A., Kazempour, M., & Allspaw, K. M. (2006). Socioscience and ethics in science classrooms: Teacher perspectives and strategies. *Journal of Research in Science Teaching*, 43(4), 353-376.
- Sadler, T. D., Chambers, F. W., & Zeidler, D. L. (2004). Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education*, 26(4), 387-409.
- Sadler, T. D. & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, 88(1), 4-27.
- Schultz, A. (1998). Caring in schools is not enough. *Educational Theory*, 48(3), 373-393.
- Sockett, H. (1993). *The moral basis of teacher professionalism*. New York: Teachers College Press.
- Simmons, M. L., & Zeidler, D. L. (2003). Beliefs in the nature of science and responses to socioscientific issues. In D. L. Zeidler (Ed.), *The role of moral reasoning and discourse on socioscientific issues in science education* (pp. 81-96). Dordrecht, The Netherlands: Kluwer.
- United States National Board for Professional Teaching Standards. (1989). *Policy position*. Retrieved March 29, 2001, from <http://www.nbpts.org/about/index.html>
- Wells, D. (1998). *Losing our virtue*. Grand Rapids, MI: William B. Eerdmans Publishing.
- Wildy, H. & Wallace, J. (2004). Science as content, science as context: Working in the science department. *Educational Studies*, 30(2), 99-112.
- Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, 89(3), 357-375.