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Troubling STEM: Making a Case for an Ethics/STEM Partnership

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Abstract Set against the backdrop of a STEM-based (science, technology, engineering and mathematics) activity in a teacher education science methods class, the author examines the need for ethics education to be partnered with STEM education. To make the case, the origin of the STEM initiative, undertaken and strongly supported by both US government and corporate sources, is briefly recounted. The STSE initiative (science, technology, society and environment) is posited as a counterpoint to STEM. Also considered are: (a) an historical perspective of science and technology as these impact difficult individual and social decision making; (b) STEM knowledge generation considered through the lens of Habermas' three-fold knowledge typology; and (c) the experiences of the teacher candidates working through the STEM activity when an ethical challenge is posed. The author demonstrates the need for a moral component for science education and makes the case for a partnership between STEM and ethics education. Further, such a partnership has been shown to increase student enjoyment and motivation for their science studies. Three possible ethical frameworks are examined for their theoretical and practical utility in a science classroom.

Keywords STEM · STSE · Science teacher education · Ethics education

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Introduction

In my science methods class, teacher candidates (TCs) preparing to teach at the elementary level are introduced to integrated STEM (science, technology, engineering and math) activities through a tower-building competition. Essentially, groups of TCs are provided the scenario that they are stranded on an island after a plane crash. The size of this imaginary island is such that its circumference can be hiked in 2 or 3 days, and it is inhabited by an indigenous population. In order to be rescued, the TCs must build a tower for the purpose of sending and receiving radio signals. After a cursory lesson on the impact of wind on tall structures, they are given limited supplies (one piece of cardstock, scissors, a meter of tape and a 10 cm square of foil) for the purpose of constructing a tower. It must be tall; it must withstand winds from the ocean; and it must support a properly shaped radio signal dish. The TCs set to work using their knowledge of science and technology, coupled with attention to mathematical factors, to engineer a tower taller and stronger than those of their peers. The mood in the classroom is one of enthusiasm and excitement; the TCs like the competitive nature of the activity and the opportunity to problem-solve in a team, with simple materials. The theme of an old TV show, *Gilligan's Island*, plays in the background.

At first glance, the tower-building activity encapsulates STEM at its finest: bright young minds eagerly working to solve a specific and important problem that requires the integrated understanding and manipulation of scientific, technological, engineering and mathematical principles and skills. It seems hard to argue with a classroom activity that elicits so much eager, collaborative work applied to a problem requiring integrated STEM skills and knowledge. Surely this is exactly the intention of STEM education. Yet, a precise definition of STEM education remains elusive: As Bybee (2013) points out, "In a sense, the context clarifies the meaning of STEM" (p. x). Sometimes, as in the tower-building activity, STEM is an integrated pedagogy of two or more disciplines; at other times, it signifies a loose connection between four separate subject areas.

Regardless of its hazy definition, I have become increasingly troubled by the STEM initiative as it is playing out both in the USA and in Canada where I reside and work. As an educator of teacher candidates in a bachelor of education program, and of elementary and secondary students, I prize the notion that education is a holistic and interconnected enterprise. No disciplines should be privileged over others, particularly as they address how humans should live sustainably and ethically on this planet. My concerns are best addressed by examining the STEM initiative from three perspectives: (1) the origins of STEM (since the circumstances precipitating the inception of an education initiative will inform its implementation); (2) an examination of the type of knowledge that is created via STEM education (using as a framework Jürgen Habermas' threefold knowledge typology); and (3) by way of a history lesson provided by Freeman Dyson, noted American physicist. I use the tower-building activity as a backdrop for a discussion of the influence of the STEM initiative on education and therefore clarify the need for STEM teaching and learning to realize the necessity of partnering with ethics education. An ethical framework for STEM would inform the decisions and directions of teachers, and teacher educators, as they navigate the sometimes confusing pathways of integrated STEM curriculum.

Guiding Literature: Investigating a Lack of Grounding in Ethics

The next three sections: the origins of STEM; Habermas' knowledge interests; and a lesson from history, will bring into focus a troubling aspect of STEM, that is, its apparent lack of grounding in ethics.

Origins of STEM

In the 2009 PISA study (OECD, 2010), US students ranked 17th in international science and math assessments, well behind countries such as Japan, Shang Hai and Korea and also behind Poland, Iceland and Canada. The 2012 PISA study (OECD, 2013) again placed US students well below the OECD international average scores in mathematics, science and reading. The poor performance of American students on the international stage continues to be a troubling state of affairs for the USA, a country that has viewed itself as a world leader politically, economically and technologically for over a century. It also explains the fierce drive to improve STEM education as a means to maintaining the nation's position as a global leader. In 2004, seeing the writing on the wall, the US Federal government invested $3 billion dollars in STEM education programs through the National Science Foundation and the National Institutes of Health (Burke & Baker McNeill, 2011). In 2011, with the re-authorization of the America COMPETES Act, the focus on STEM education was renewed, and industry responded with enthusiasm. A coalition of CEO's of some of the wealthiest and most influential companies in corporate America (e.g., Xerox and IBM) launched Change the Equation, a philanthropic powerhouse that provides both money ($5 million in its first year) and programming to inspire STEM education. This is in keeping with the dual charge by the President's Council of Advisors on Science and Technology (PCAST, 2010) to inspire students and prepare them for careers in STEM.

But one should ask: *What are students being prepared for? What are they being inspired for?* In the *Report on STEM Education*, Machi (2009) clearly and specifically identifies US industrial and defense capabilities as being seriously impaired by the decline in US students' interest in STEM education and STEM careers. In his January 2011 State of the Union Address, President Obama said, "We need to out-innovate, out-educate, and out-build the rest of the world." Echoing the President's words, Change the Equation insists that "STEM is the future. STEM learning is an economic imperative." A 2011 US Whitehouse government blog states: "The decisions we make today about how we invest in research and development, education, innovation and competitiveness will profoundly influence our nation's economic vitality, global stature and national security tomorrow." As it is reflected in the both political and industrial national discourses, the origin and intention of STEM education and knowledge generation in the US is, undeniably, to buttress national economic and military capacity.

But, STEM education is not a comprehensive form of knowledge, despite the interdisciplinarity implied in the acronym. In the same way that scholars have taken up the study of the nature of science in order to clarify its parameters and limitations, the "nature of STEM" also requires further definition and explication. For this task I look, in part, to the work of Jürgen Habermas.

Habermas' Knowledge Interests

Habermas (1971) categorized human knowledge using a threefold typology of "knowledge interests," based on his proposition that all knowledge is circumscribed by the interests of the humans who generate and use it:

> The specific viewpoints from which…we apprehend reality ground three categories of possible knowledge: information that expands our power of technical control; interpretations that make possible the orientation of action within common traditions; and analyses that free consciousness from its dependence on hypostatized powers. (p. 317)

The first of the knowledge interests is focused on the human need to survive and thrive through "information that expands technical control" (ibid). Certainly, the knowledge embedded in STEM disciplines does just that, enabling us to use natural resources and control environments to our benefit. Humans have created, as examples, complex habitation and transportation infrastructures and food production systems, based on our knowledge development in the STEM disciplines. Science curricula, for example in Ontario, Canada (OME, 2007, 2008), demonstrate Habermas' first knowledge interest; they provide logical and sequential frameworks for content knowledge acquisition in classrooms.

Habermas' second knowledge interest encompasses the human need to communicate knowledge among ourselves and come to some agreement around issues of language and social structure. The STEM disciplines themselves have a well-developed, arguably hegemonic scientific symbology, and STEM disciplines currently hold a privileged place in the knowledge hierarchies of the western world (Gruenewald, 2004).

In his analysis of Habermas' work, Crotty (2010) posits that the first two knowledge interests function together to maintain the status quo. This certainly seems to be the intention of the STEM initiatives in the USA as evidenced by the stated desire to continue in a dominant international economic, political and military position. However, Habermas' third knowledge interest should give STEM proponents some pause.

The third knowledge interest is of an emancipatory nature. It encourages critical self-reflection and addresses human responsibility regarding the use of the knowledge that is generated and communicated.

> The only knowledge that can truly orient action is knowledge that frees itself from mere human interests and is based on Ideas – in other words, knowledge that has taken a theoretical attitude. (Habermas, 1971, p. 310)

The third knowledge interest enables choice-making for what lies ahead. "It is precisely by imagining a future and taking steps to achieve the imagined future that humans can break out of the cultural system into which they have been socialized" (Crotty, 2010, p. 635). It is the third knowledge interest that I believe underscores one of the weaknesses of the STEM initiative: As imagined by advocates of STEM, the future will be one of management and maintenance of the status quo for the USA as world leader. In the service of a nation, the imagined future will continue to accede prestigious positions to STEM disciplines rather than encouraging a critique of that hegemony. Such an approach is neither emancipatory, nor does it recognize a need for a critique of past political and economic strategies. Unfortunately, the generation of knowledge associated with the STEM disciplines has, in the past, been co-opted for the purpose of lining the pockets of the already powerful and resulted in collateral damage that includes laying waste natural environments and further disenfranchising societies in the developing world. Most would agree that our future requires careful and thoughtful consideration, yet at this point we might be most enlightened by looking to the past.

A Lesson from History

In the study of STEM pedagogies, it is often instructive to open the doors of interdisciplinarity and take a lesson from history. In his book *Disturbing the Universe* (1979), Freeman Dyson, a distinguished American physicist and author, acknowledges that science cannot be separated from the politics of human agency, which, in so many cases, drives science forward. "We are scientists second and human beings first. We become politically involved because knowledge implies responsibility." (p. 6) Dyson takes this idea further by suggesting that it is the obligation of the scientist (and I would add the STEM-literate teacher and citizen) to realize that STEM endeavors cannot be separated from a moral conscience. Reflecting on his time working as a technician in WWII British Bomber Command (which enabled the devastating destruction of cities like Dresden), Dyson recounts the burden of a moral conscience and the eventual collapse of his moral framework:

> I began to look backward and to ask myself how it happened that I let myself become involved in this crazy game of murder…At the beginning of the war I fiercely believed in the brotherhood of man, called myself a follower of Ghandi, and was morally opposed to all violence. After a year of war I retreated and said, Unfortunately nonviolent resistance against Hitler is impracticable, but I am still morally opposed to bombing. A few years later I said, Unfortunately it seems that bombing is necessary in order to win the war, and so I am willing to go to work for Bomber Command, but I am still morally opposed to bombing cities indiscriminately. After I arrived at Bomber Command I said, Unfortunately it turns out that we are after all bombing cities indiscriminately, but this is still morally justified as it is helping to win the war. A year later I said, Unfortunately it seems that our bombing is not really helping to win the war, but at least I am morally justified in working to save

the lives of the bomber crews. In the last spring of the war I could no longer find any excuses. (p. 31)

Yet arguably, the most anguish-laden bombing of that war came in 1945 with the nuclear destruction of Hiroshima and Nagasaki. Dyson recollects the energy among the scientists at Los Alamos who designed and built those bombs: “While the work was going on, they were absorbed in scientific details and totally dedicated to the technical success of the project. They were far too busy with their work to worry about the consequences.” (p. 52). The image of morally near-sighted scientists, funded by their government for military/political gain, is troubling in itself, but certainly neither inconceivable nor surprising. However, it is Dyson’s further commentary that is particularly chilling: “But they did not just build the bomb. They enjoyed building it. They had the best time of their lives while building it.” (p. 53). This image of scientists at work, happy to be entirely absorbed in their scientific endeavors, ceding their moral position to government/military, should give all STEM educators pause. We need to continue to ask ourselves the questions: *What are students being prepared for? What are they being inspired for?* History teaches that the STEM disciplines, pursued with a narrow focus on knowledge creation, become a seductive enterprise that can have unforeseen and horrific impacts on the lives of millions. With this history lesson in mind, we return to the classroom of TC tower builders to check on their progress.

Methodology

The basis for the ideas put forward in this piece is based on my observations of TCs engaged in the learning experience of collaboratively constructing a tower out of cardstock. The activity has taken place numerous times over a 6-year period, in a number of permutations, and with varying outcomes. The requirement for an Impact List adds a layer of complexity that opens the door to considerations of morality and ethics, as described in the following section.

A Challenge for the Tower Builders

As with many classroom construction projects, such as building the strongest bridge or creating the model airplane with the straightest, longest flight path, students are encouraged by the teacher to focus all of their knowledge, skill and creativity on the task at hand. There is no hint that a stronger bridge or a better airplane should be anything but beneficial for its builders.

Halfway through the tower-building activity, I introduce another element to the competition. The TCs are reminded that they are on an inhabited island and that, as they continue building, they must also consider and list the impacts that their stay will have on the island and on its indigenous population. By creating such a list, it is my intention to challenge the tower builders to consider the wide-reaching effects of their enterprise, that is, to introduce the idea that such an enterprise might require moral choices and an ethical position. Some groups relegate the Impact List task to the TC with the least inclination for engineering, while other groups begin an animated discussion as they work. The assignation of responsibility for the Impact List mirrors STEM endeavors past and present: In some cases, as in the Los Alamos Lab, impacts and ethics were left to the non-scientists. In my classroom, where non-science majors far outnumber the science majors, there is genuine interest among many of the participants to deliberate over the consequences of their imaginary stay on the island.

The resulting lists of predicted impacts are telling. They reveal prevalent and deeply ingrained attitudes about the competitive, unsustainable and colonizing legacy of a historical version of STEM. Most groups identify that their stay may strain the food and natural resource supply on the island, certainly create waste and possibly introduce new pathogens. Some groups will suggest that the native populations will benefit by being exposed to new technologies and learning about new medicines. There is an overarching assumption that the tower builders can go about their task and actually build the tower without negotiation or acknowledgement that they are inhabiting the space previously occupied by others. The TCs work within a paradigm in which they have an implicit right to cut the trees, build their shelters and harvest the food on the island. For the most part, their imagined interactions with the inhabitants are treated as necessities to furthering their own interests.

Of course, there are exceptions, and these can also be revealing. One group of young women completely gave up on building a tower and decided that they would survive by marrying into the native population. They had no interest in the STEM initiative of tower building and felt that, given their social abilities and feminine wiles, they could live out their lives happily on the island as wives and mothers. In another session, during a discussion of relationships between the islanders and the castaways, a young First Nations woman in my class asked her peers why they thought the indigenous people on the island would need or want new technologies or medicines. Her hinted reference to her people's colonized past became a powerful moment for the class as they made the connection between their imaginary activity and her historic reality.

An occasional variation of the activity, in which a group of TCs take the role of islanders who consider the impact of the tower builders on their island, further exposes the differing perspectives between the indigenous population and the tower builders. The intention of the variation is to highlight the likelihood that the island culture has developed its own unique sciences and skills as means to survive and thrive. However, young people whose culture has not been "colonized" are working from a disadvantaged position when taking the point of view of an islander; they guess at what the impacts might be like for their island life. They are certainly never asked for their suggestions as to how to get off the island, or be rescued. While it is useful to have the TCs tackle this position, whenever there is a (self)identified First Nations TC in the class I prefer to include this variation by asking them to take the perspective of an islander when generating the Impacts List. Their insights, based on their understanding of a history of colonization, add an important cultural element to the learning.

Analysis: The Trouble with STEM

While both economic and military capacities are justifiable national priorities, it is instructive to attend to what remains unsaid. American STEM rhetoric does not focus on making a better world, or a sustainable world, or improving the lives of oppressed around the world. The discourse focused on STEM initiatives neither explicitly nor implicitly addresses pressing global issues. Perhaps there are reasons that STEM seems distasteful to students, beyond teachers who have been targeted as unprepared to teach those subjects. The young people with whom I have worked have often been drawn to causes bigger than themselves, to building a better world, and taking seriously their responsibilities as global citizens.

Despite its claims of interdisciplinarity, STEM exerts a single-minded focus on science, technology, engineering and math as the means to strengthening American national interests nationally and globally. The intention that STEM education will improve the lives of people, or environments, both locally and globally is largely ignored, unless it is in the best interests of American generation of wealth and national defense. Fortunately, there is a growing awareness that the STEM drive must be tempered by a balancing drive from the Humanities and Social Sciences (Johnson, 2010). Single mindedness will not serve a human future as well as a holistic approach informed by many and varied voices.

To that end has come a call for socio-scientific studies within STEM curricula, these examine STEM issues in social and environmental contexts and have as their goal "education for citizenship" (Levinson, 2006). Studies that examine the impacts of Science and Technology on Society and Environment (STSE), embedded in science teaching and learning, have become common in many curricula in, for example, Canada, the UK and Australia (Driver, Newton, & Osborne, 2000; Kolstø, 2001). Of particular interest to this paper is that STSE studies tend to bring into focus the moral position of an individual and/or the society in which they live. When called upon to critically analyze social and environmental issues, and cases that result from STEM activities (e.g., embryo design, or genetically modified foods), students often find themselves faced with making moral choices (DeLuca, 2010; Herreid, Schiller, & Herreid, 2012; Reiss, 2010).

In a recently published workbook called *Science Stories: Using Case Studies to Teach Critical Thinking* (Herreid et al., 2012), there is an entire section, comprising eight cases, devoted to applying ethics and the scientific method to individual cases. The cases are based on actual events and come with prepared questions for students and notes for the teacher. The careful preparation and presentation of such a workbook for teachers in the STEM disciplines is laudable since it provides them with the tools (cases, guiding questions, extra notes) for classroom implementation. However, not present in the workbook is mention of the study of ethics as a discipline, with a methodology that includes various lines of reasoning, and a system of frameworks that might be applied in various situations. One could argue that, without explicit ethics education, including possible ethical frameworks to guide moral choices, neither teachers nor their students are fully prepared to engage in the task of case analysis; thus, ethics education continues to be elusive in classrooms. Nonetheless, it is not entirely absent; there are doubtless many morally motivated, thoughtful educators who understand the need to introduce their students to issues that require critical and ethical thinking.

The argument here is that ethics education should not remain implicit in curriculum, addressed occasionally by a handful of teachers; rather, ethics education should be incorporated with cogency in curricular documents. Ethics education should take its place in a partnership with STEM studies; it is critical to provide our students and their teachers with the tools to critique STEM activities and directions and to make wise choices as global citizens. The question then becomes: What might ethics education for a STEM partnership, look like?

Ethics for STEM

Herreid et al. (2012) describes ethics simplistically as dealing with "questions of good and evil, right and wrong, virtue and vice, and justice and injustice" (p. 268). The dualism implied by those words suggests a way of thinking that does not do justice to the complexity of most ethical dilemmas, and may therefore compromise the process of critical analysis. In my experience, the young people who engage in our classrooms are often passionate about their choices, but at the same time are still developing their ethical reasoning abilities (Reiss, 2010). To present *either/or* choices regarding ethical dilemmas does not support students' progress in learning to make complex reasoned decisions.

Ethics is defined by Reiss (2010) as "a branch of philosophy concerned with how we should decide what is morally wrong and what is morally right" (p. 7). While apparently dualistic in nature, Reiss' definition focuses on the decision-making process and links the concept of morality to a critical analysis of actions in particular circumstances. Critical analysis can take a number of different paths of reasoning; indeed, there is more than one ethical framework that would inform and support STEM studies. However, the intention of this paper is not to present a comprehensive inventory of ethical frameworks, rather to put forward the benefits of partnering STEM with ethics education in teacher education. Along with content and skill-rich STEM learning, DeLuca (2010) asserts that teachers can provide their students with "robust ethical frameworks for understanding and appraising applications and implications…" (p. 87). The next section examines three ethical frameworks particularly suitable for the integrated STEM classroom and applies these to the work of the tower builders.

Consequentialism

Reasoning through an ethical dilemma using a framework based on consequentialism requires an interrogation of possible outcomes of the decisions being made. Questions might include:

Who or what is affected by this issue?
What are the benefits involved?
What are the harms for those involved?

Are some consequences greater or lesser than others?
If one is harmed and another benefits, how do you decide who or what matters most?
(McKim, 2010, p. 31).

Additional questions might be:

Can we know all of the consequences of actions with respect to the issue of focus?
Is there a legitimate time-frame within which to consider the consequences of our actions?
What should you do to be sure your actions are based on a full consideration of the consequences?
(Steele, Brew, & Beatty, 2012)

The secondary assignment to the tower builders in my classroom, to determine the impacts of their presence on the island, is rooted in the consequentialism framework. Based on their combined prior personal knowledge gained as a result of their undergraduate studies, the TCs have to brainstorm the environmental and social consequences of their living and working on the imaginary island. One of the benefits of using the consequentialism framework is the resultant consolidation of STEM content knowledge and skills. Consequentialism, partnered with a STEM topic in an elementary or secondary classroom, offers students starting points for further investigations that will allow them to reason from well-informed positions. For example, in deciding on the acceptance of genetically modified foods, questions such as *What are the benefits involved?* and *What are the harms for those involved*? provide students with further directions for investigations into the specific technologies used in genetic manipulation.

Virtues Ethics

Virtues ethics support and build on character education, which is itself a recent initiative in education. Within a virtues ethics framework, reasoning is based on which characteristics constitute a morally "good" or virtuous individual. For example, it is morally correct for a teacher to be fair to all students, rather than favoring all of the girls, or all of the Toronto Maple Leafs supporters (Reiss, 2010). Questions that might be asked within the virtues ethics framework are:

How would you define a person of good character?
What would a person of good character do in this situation?
What characteristics or qualities would we want a person to manifest in this situation?
How might a person of good character make questionable ethical decisions in this situation?
Who decides what are the ideal qualities of a person with good character in this situation?
What would you do in this situation?
(Steele et al., 2012)

We would generally agree that most people see themselves as “good” people and would want others to see them that way as well. For the tower builders, the virtues ethics framework informs their decision making by urging them to consider the actions of a morally good person in their situation. For example, if one of the islanders were to have an illness or injury that could be healed by the tower builders, a morally good person would provide that healing. But given the loss of traditional healing and medicine expertise in the face of advancing Western medicine, one might additionally ask: Would a morally good person expose the islanders to Western medicine at all? Would a morally good person value and respect indigenous medicine to the point of agreeing to withhold Western medicine?

Sustainability Ethics

With an increasing interest and need to consider the limitations of the planet’s resources, and the Brundtland Commission’s (1987) directive that those living now shoulder a socio-environmental responsibility for future generations, it is not surprising to find a branch of ethics tackling issues of sustainability. According to Kibert, Monroe, Peterson, Plate, and Thiele (2012), a sustainability ethic addresses the future by juxtaposing the needs and rights of the present with the needs and rights of the future.

Questions that might frame sustainability ethics are:

> Can individuals living in the future have rights?
> How is it possible to address the needs of future peoples when the needs of the vast majority of the world’s present population are not being met?
> What exactly are the “needs” that must be met and how might these be prioritized?
> (Kibert et al., 2012, p. 15).

We can also ask:

> Should we only consider the future rights and needs of humans? What about animals? Plants?
> Does the ‘environment’ have rights?

Sustainability ethics might also find purchase in Habermas’ third knowledge interest regarding the choices we make for the future. By asking some of the questions posed above, we bring clarity to the significance of our STEM knowledge and further understand the responsibility such knowledge imparts for future choices. The TCs’ tower-building exercise does not grapple with sustainability ethics until the Impact List challenge is introduced. At that point, the TCs have to consider a picture broader in scope, not just for their present circumstances, but also for possible futures. Admittedly, the premise of the activity is that they should be rescued and leave the island rather quickly, a scenario that downplays the need for sustainable choices. However, the lasting impacts of their activities might reach far into an imaginary future for the island inhabitants and environment. The TCs are asked to consider consequences that might play out long after they have departed.

Discussion: The Time for Ethics Education

At what point in their science and math studies should students be introduced to ethics education? This is a fair question and has been tackled by a number of developmental theorists, with exceptional research done by Lawrence Kohlberg (Crain, 1985). Kohlberg (1975) identified a number of stages in the moral development of individuals, beginning with a simple, externalized view of right and wrong and moving toward an internalized system of principles for a "good" society. Of interest to educators is Kohlberg's contention that progress through the six stages of moral development is not related to maturation or socialization, but as a form of cognitive development, it can be significantly impacted by education. Students need to actually engage in the "cognitive conflict" that proceeds from grappling with an issue, which further encourages them to progressively develop their ideas of morality and ethics.

> As children interact with others, they learn how viewpoints differ and how to coordinate them in cooperative activities. As they discuss their problems and work out their differences, they develop their conceptions of what is fair and just. (Crain, 1985)

In addition to Kohlberg's stages, Reiss (2010) suggests that as students move through degrees of moral development, they also are able to: (a) use more than one ethical framework; (b) determine which is most useful in a given situation; (c) include forms of life other than humans in their deliberations; (d) consider long term outcomes; and (e) integrate scientific knowledge and ethical principles. In a study of ethics education aimed at young students aged five to ten, Bunting and Ryan (2010) found that even young children can reason and justify their choices, as long as the ethical issue being studied is familiar to the student. It is thus appropriate to introduce ethics education at an early age in schooling, realizing that students must be supported as they examine complex issues, and with the understanding that a moral conscience needs to be developed, since it is not innate.

The ability to reason morally within an ethical framework at a sophisticated level is a skill that requires nurturing and refining throughout one's life. The assumption that all adults, indeed that all teachers, fully and consistently understand and act on their personal system of principles is ill-informed. This has significant implications for teacher training, as suggested by Bunting and Ryan (2010):

> …successful implementation (of ethics education) seems to centre on teacher knowledge in both the planning and implementation of authentic classroom experiences. As such the teacher needs to be able to integrate knowledge of the issue or topic with knowledge of ethical reasoning approaches. (p. 52)

Bunting and Ryan recommend professional development workshops to train teachers in integrating ethics education within existing curriculum and, further, advocate for ongoing support for those educators. However, given that most teacher candidates have not had explicit ethics education, it would seem expedient to introduce ethics during initial teacher preparation and further, to partner it with STEM education during that training period.

Implications: Engaging Students and Teachers

Perhaps one of the strongest arguments to be made for partnering STEM with ethics education is that such an approach will intrigue and engage students (Herreid et al., 2012). As discussed earlier, STEM topics can often be coupled with socio-scientific, or STSE issues. Research suggests that an STSE perspective on STEM provides a pedagogical avenue that has been shown to increase student enjoyment and motivation for their science studies (Herreid et al., 2012; McKim, 2010).

> There is a price to pay for our typical approach in science, technology, engineering and math education, and for our devotion to facts, the lecture method and multiple choice tests…Science majors have a high tolerance for boring material that seems to have nothing to do with their lives - a kaleidoscope of facts without apparent rhyme or reason… (Nonscientists) are not intrigued by the detailed structure of the atom or the cell. It is not that they do not think it is important; they simply do not see why it should be important to them. We have not shown them how the cavalcade of facts relates to global warming, the debate over creationism versus evolution, natural disasters, cancer, AIDS, sex, or anything else they might care about. (Herreid et al., 2012, p. x)

Given the concern that high numbers of students seem to be opting out of STEM courses and programs (PCAST, 2010), the premise that disciplines, such as science and math, coupled with STSE and informed by ethics education will keep students enrolled and engaged in STEM programs, should be enthusiastically explored. Moreover, when students can tackle their studies in formats that more fully integrate learning within STEM disciplines, STSE perspectives and critical thinking informed by ethics education, their learning is authentic and contextual.

One last visit to the tower builders in my classroom provides substantive evidence that the partnering of integrated STEM learning with STSE/ethics education has potential for student and teacher engagement. The TCs comment on how much fun they had building the towers, but add that deliberating over the list of their impacts on the island added a necessary and important component to their task. As they learn to become educators, the TCs increasingly see their own learning through a teacher's eyes. They recognize and value opportunities for integration, particularly when those opportunities incorporate critical thinking and ethical decision making.

Conclusion

In summary then, the STEM education initiative has its origins in the American desire to boost student interest and participation in science and math as a means to maintaining economic prosperity and strengthening national defense. However, inasmuch as the STEM initiative addresses human knowledge interests in the past and present, Habermas' third knowledge interest points out the inherent weakness of the current approach, which is the lack of an explicitly stated, thoughtfully considered and ethically reasoned global emancipatory future. And history provides examples of how easily the shortsighted/insular pursuit of STEM disciplines can yield destructive instruments that, in turn, bring forth unintended consequences and moral conflict.

STEM educators should continue to ask the questions: *What are students being prepared for? What are they being inspired for?*

The tower-building activity intimates that STEM education has global repercussions that require the development of global sensibility and responsibility by both students and their teachers. STEM studies must be balanced: STEM education needs to be informed by the humanities and most importantly by ethics, and this should be explicitly reflected in teacher preparation courses. A partnership between STEM and ethics education, through direct teaching of ethical frameworks such as virtues ethics, consequentialism and sustainability ethics, is strongly advocated for teacher training and development. Ethics education can be introduced to students at an early age, and should support student moral development and ethical decision making throughout the years of schooling. It follows that teacher development in this respect is essential, and should be part of teacher training.

Pursuing the STEM/ethics partnership is very worthwhile for many reasons, of which the most obvious is that students clearly are intrigued and motivated by the opportunity to grapple with difficult socio-scientific issues that require interdisciplinary critical thinking and moral reasoning. This addresses the immediate concerns that precipitated the STEM initiative—students who do not seem to be interested in pursuing STEM courses or careers. However, clearly teacher education and ongoing professional development are necessities for the STEM/ethics partnership, as is the need to root these thoughtfully and masterfully in curriculum. Because, most importantly, a STEM/ethics partnership will support the development of teachers who are STEM-literate and morally mature; teachers who are able to support their students in taking global as well as a national perspectives on STEM-related issues, thus enabling them to become capable and informed ethical decision-makers.

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