

# CHAPTER 13

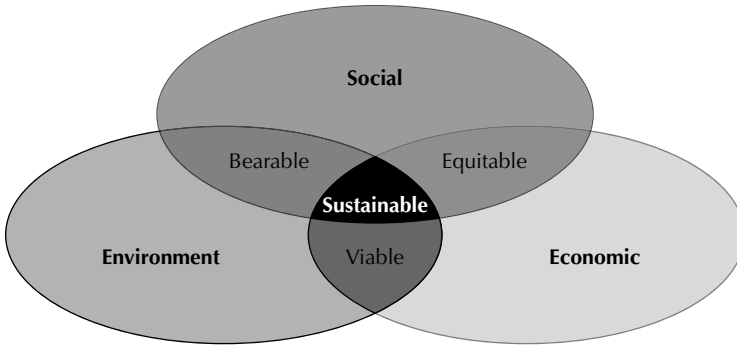
## International STEM Education for Global Sustainability

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### INTRODUCTION

On a daily basis, people around the world face challenges that result from us all, together on our small planet, approaching the carrying capacity of our environment. The sustainability of humanity is determined by our ability to keep in balance the three pillars of society — our environment, and our economic and social systems. The social and economic costs of environmental degradation are very real to individuals, communities and economic endeavours. Similarly, economic systems based solely on exploitation, without consideration of resource depletion and community impacts, can have drastic impact on environmental quality and the quality of life in communities. As Jared Diamond has aptly demonstrated in his book, *Collapse: How Societies Choose to Fail or Survive* (2005), societies that ignore the intimate feedback between environmental problems and economic and social structures risk driving themselves to collapse. As noted by historian Arnold Toynbee in *A Study of History* (1961), “civilizations die from suicide, not by murder” when they fail to meet the challenges of their times. Or, as noted by historian Barbara Tuchman in *The March of Folly: From Troy to Vietnam* (1984), “A phenomenon noticeable throughout history regardless of place or period is the pursuit by government of policies contrary to their own interests.”

- Were any of us prepared for understanding the interconnectedness of societal systems through our education, prior to our university experience?
- Is the small fraction of the global population that enters research universities the only segment of society that needs to understand this?



- Do we recognize the need to have a global population that understands the principles of sustainability, so they have a chance to put them into practice in their lives?

This paper argues that education and global sustainability are a coupled set — you can't achieve global sustainability without widespread sustainability education. Furthermore, education for sustainability must include STEM disciplines as well as humanities and social sciences, be made available internationally, and must be available where the bulk of the population is — namely at the primary and secondary levels — if we are to have any chance of making meaningful progress towards global sustainability.

The paper examines the sad state of education today globally, as well as economic, political and geopolitical complicating factors, and highlights the difficulty in educating for global sustainability when education itself appears increasingly to be unsustainable. Finally, the paper notes that leadership is desperately needed in advancing widespread sustainability education. Research universities have a key role to play in this arena — not only through education at the undergraduate and graduate levels, but also by building, testing and implementing successful programs that advance sustainability and sustainability education at the primary and secondary educational levels and through community engagement.

## GLOBAL SUSTAINABILITY AND EDUCATION

### Thoughts on Sustainability

Sustainability has been defined as “*Meeting the needs of the present without compromising the ability of future generations to meet their own needs,*” (Our Common Future, 1987). Because of the wide range of human needs, as well as the economic, social and environmental systems associated with satisfying and managing them, sustainability is inherently interdisciplinary at the largest scale.

Achieving sustainability solutions for humanity requires innovations involving not only science and engineering, but also economics, history, government, cultural studies, psychology and ethics, among other fields.

As John Muir once said (1911): “When we try to pick out anything by itself, we find it hitched to everything else in the universe.” Pollutants travel the globe, emitted from factories on one continent only to pollute another. Excessive consumption of scarce resources by one country can have drastic consequences for other countries — whether per capita fossil fuel consumption in the U.S. and our resultant climate change debt, the conversion of ethanol for fuel in the U.S., reducing the availability of essential food stocks in Latin America, or the use of rare Earth minerals in industry and construction in China, and the resultant impact on availability of these resources in other countries. A massive, but not unimaginably large earthquake (USGS, 2011) and resultant tsunami inundate thousands of square kilometres of Japan including aging nuclear reactors unwisely placed on coastal, low-lying ground, producing a nuclear incident which threatens to put a widespread global halt on use and expansion of one of the most effective methods we have of producing energy without greenhouse gas emissions — a solution we desperately needed to address our climate change problem. We now know that we can’t have a truly sustainable society at a local or national level — sustainability can only really be achieved on a global level, because the systems that are required for sustainability are interconnected and global.

Furthermore, unless sustainability, which inherently has the implication of maintaining the *status quo*, is approached from a perspective that addresses equity concerns and the aspirations of people, invariably some individuals and communities may not see the value of achieving global sustainability. Why would someone want sustainability, when they are on the bottom of society? The relative attractiveness of individual actions, when you have the choice of improving your quality of life through increased resource consumption or deferring your own consumption in the interests of unknown others on a global scale, is hard for people who have already been blessed with access to resources for generations to deal with. How much more difficult is it for those that have never had access to even a marginal quality of life to forgo the opportunity to improve their lot, relative to others? Attaining sustainability inherently requires an approach that facilitates the advancement of populations locked in poverty, suffering widespread governmental mismanagement, and with minimal access to education and opportunity.

The concept of sustainability is to some extent inherently at odds with the cultural mantra of freedom, accepted widely in Western society. If freedom or “liberty” is your core value (Jefferson, 1776), and it means being able to do anything you want to maximize your happiness and success independent of the impact of your actions on anyone else, then the concept of sustainability

may threaten your core values. Because these values are deeply embedded in culture and family, and because values are formed when we are young by teaching and example, developing the values that are needed to move individuals to accept and act on approaches to global sustainability needs to begin when people are young, and leverage the tools that we have to impact young people. These include (but are not limited to) primary and secondary schools and educators, parents and grandparents, social and community organizations, religious communities and social media.

### **Education for Advancing Global Sustainability — Youth, Multi-disciplinary and International**

Traditionally, education at all levels has been stove-piped into independent disciplines, with relatively little opportunity for interdisciplinary approaches except at the highest level. Not only are the Humanities, Social Sciences and Physical Sciences taught essentially in different worlds, but even within these worlds, there is little enrichment or cross fertilization between closely related disciplines. As a result, it's not surprising that students finishing secondary education have little knowledge of systems, let alone complex and interrelated ones. The large majority of students at the secondary level typically have little to no formal educational exposure to thinking about the interconnected systems that bind together the environment, economic and social systems, nor the opportunity to consider their complex interactions and scenario-based outcomes.

But why should this emphasis on sustainability begin in the primary and secondary levels, instead of waiting until students reach the university? As we know, while a significant fraction of young people in the developed world have the opportunity to have a university education, a significant fraction of young people drop out of high school. In the U.S., high school dropout rates ranged from 4% to 11% across the country in 2009 (Datacenter, 2009), with the dropout rate for black and Hispanic students (9.6 and 17.6, respectively) significantly higher than for Asian and non-Hispanic white students (Child Trends Data Bank, 2011). In 2006, the national on-time high school graduation rate — the percentage of entering ninth graders who graduated 4 years later — was 73% (Stillwell & Hoffman, 2008). Internationally, the Organization for Economic Co-operation and Development (OECD) provides reports on education systems, approaches and student attainment across OECD countries, many of which have reached a high level of economic development. *Education at a Glance OCED 2010 Indicators* (2010) reports that across OECD countries, an average of 80% of students complete upper secondary education, ranging from 26% in Turkey to 97% in Germany. Of these students, an average of 56% of secondary graduates entered the equivalent of a four-year college or university in OECD countries, ranging from 25% in Luxembourg to

83% in Poland (in the U.S. in 2008, 69% of high school graduates had enrolled in an undergraduate education program the fall following graduation). (National Science Board, 2010). This means that in OECD countries, on average, only 45% of young people enter college — and even fewer complete their undergraduate education. For those who drop out of the educational system before university, the education they receive in primary and secondary school is likely to be the intellectual toolset they carry with them the rest of their lives. These numbers reflect the graduation and tertiary enrolment rates mainly in developed countries. We can expect that the number of students completing secondary education and continuing to college in less-developed countries to be much lower.

Finally, because leading individuals towards sustainability involves consideration of values, and the formation of values takes place mainly when we are young, weaving consideration of values into education across disciplines in the primary and secondary level is an essential and too-long neglected component of education at these levels (Fulghum, 1990). This is particularly important in the area of sustainability education, in which we need to encourage individuals to temper their urge to act solely in their immediate self-interest and, instead, to modify their behaviour in the interest of others, the environment and society in general.

If we are to have any hope to bring the difficult concepts of sustainability to the largest possible audience of learners globally, it must begin in the primary and secondary levels.

## **EDUCATION FOR SUSTAINABILITY WHEN EDUCATION ITSELF IS NOT SUSTAINABLE?**

### **Are We at a Breaking Point for U.S. Education?**

The previous section argues that, in order to have any realistic prospect of achieving global sustainability, education for sustainability must begin with youth, leveraging the tools we have to impact young people. Prominent among these are K-12 educators, with whom a significant fraction of students' time is spent before reaching majority. In order to advance sustainability education for this critical cohort, an effective strategy would be to work with teachers, providing professional development and support networks to assist them with integrating concepts of sustainability across the curriculum. Today's teachers, not unlike many of their students, have also had minimal exposure to the concepts of coupled systems and unanticipated outcomes that underlie sustainability issues — they similarly need help mastering these concepts, so they can bring them confidently to their students to facilitate their learning.

Unfortunately, these days in the U.S., K-12 teachers feel like they are under attack. A significant fraction of the U.S. population appears to not be willing to increase school funding to the level needed to adequately support K-12 education through increased tax rates, even if it is their kids who suffer the consequences. (According to the *New York Times* [2008], in the 2008 Vice Presidential debate with Joe Biden, Sarah Palin suggested that it was not patriotic to pay taxes). Facing the loss of collective bargaining rights, tenure, health and retirement benefits, coupled with stagnant or falling wages while teaching positions are cut and class sizes balloon, it's not hard to understand why teachers are demoralized. States and school districts across the country can't afford to support the teachers needed for the curriculum as it exists today, let alone to revise and extend the curriculum to integrate sustainability.

At the university level, the cost of a university education is rapidly moving out of reach of a large fraction of graduating high school seniors. In the U.S., the norm for private or out-of-state tuition at "public" universities is ~\$50K per year. While a few families may have these resources stashed away for their children, and some families can qualify for financial aid based on severely limited financial resources, a large portion of the remaining class of graduating seniors finds the option of a first class education at a liberal arts college or research university out of the question. As a result, students and families are incurring significant debt to finance their education. With the current prolonged economic recession, there is no longer the assurance that quality, high paying jobs will be available after graduation from college, which will allow the students to repay this debt. Nevertheless, because the possibility of increased tax revenue appears to be out of the question, state governments find themselves needing to continually slash funding for state colleges and universities, shifting more and more of the burden of increased costs onto students and their parents.

Given the apparent unwillingness of a significant fraction of the U.S. public to provide support for improved education at the K-12 or university level, and the limits on financial resources of individual families, we appear to be approaching a point where a major paradigm shift is needed in our approach to education. Indeed, many would argue that this shift is already underway to some extent at the university, and even K-12 level, with the growth of alternative internet-facilitated learning systems which bypass the traditional institutions of learning, for better or worse, and replace them with distance-learning and remote mentoring.

### **Reflections on the Status of Education Globally**

Of course, educators in the U.S. are comparatively lucky. In many schools in less-developed countries, teachers may not even have running water or floors in their schools, let alone books, paper and pencils, or computers to use with their students. (ICSU, 2011). There are enormous variations in the quality of schools

globally, from very well equipped establishments to those that may not even have a proper classroom for its students. A large proportion of parents in developing countries are unable to have their children admitted to the better-equipped schools because of a lack of financial resources or cultural constraints.

International studies of student achievement provide some insight into the relative success of educational efforts in a wide range of countries globally, lending support to the assertion that investment in education, and respect for education and educators, result in positive learning outcomes. OECD's Program for International Student Assessment (PISA) and the International Association for Evaluation of Educational Achievement's Trends in Mathematics and Science (TIMSS) studies demonstrate that average students in more developed economies have higher achievement scores than those in the emerging and less developed countries. While most OECD members are the economically developed countries, the PISA 2009 test had participation not only from 34 OECD countries, but also 41 countries or economies outside the OECD. PISA tests a representative sample of 15-year-olds in each country every third year, and assesses students' levels of scientific, mathematical and reading literacy and not with respect to the school curricula in the participating countries (OECD, 2010a, b). TIMSS aims to test mathematics and science achievement that is broadly aligned to the school curriculum, given that all test items are used in each of the participating countries. Fifty-nine countries (37 for grade 4 and 50 for grade 8) from all continents took part in TIMSS 2007 (TIMSS, 2007).

Finland, which ranked at or near the top in successive PISA testing from 2000-2009, attributes (FNBE, 2011) their success to multiple factors — structural and cultural:

- equal educational opportunity for all students irrespective of domicile, gender, financial situation or linguistic and cultural background
- a five-year program of Master study for all teachers, including at the primary level
- very high social status for teachers (although not necessarily very high salaries)
- becoming a teacher is the highest priority among young people, and only the top performers at school become enrolled in teacher education
- high expectations and hope, but also high unemployment rates among young people after the political shifts around 1990 provided an atmosphere where young people (and their parents) understood the significance of getting a good education.

In PISA 2009 (OECD, 2010a, 2010b), the top scores in science were achieved by Shanghai-China, followed (in order) by Finland, Hong Kong-China, Singapore, Japan, Rep. of Korea, New Zealand, Canada, Estonia, Aus-

tralia, the Netherlands, Chinese Taipei, Germany, Liechtenstein, Switzerland, the United Kingdom, Slovenia and Macao-China. All these were well above the OECD average. The top scores in mathematics were achieved by Asian countries and Finland. The countries with the highest overall reading performance — Finland and the Republic of Korea, as well as Hong Kong and Shanghai — also have among the lowest variation in student scores. Asian countries that appear to share positive attitudes towards the value of education consistently perform better in PISA test results.

These results show that in at least some countries around the world where education and educators are respected, where they are provided the tools and the training needed to provide quality education, and are reasonably well-paid, students demonstrate higher achievement levels in multiple disciplines than where this is not the case.

### **Education for Sustainability is Essential — But We Must Also Save Education Itself**

Education is essential to move humanity to global sustainability, and this education must start when the bulk of the population is still in school and forming their values. Yet we seem to face insurmountable challenges to merely adequately fund education as it is today — let alone to improve it to the point where we can integrate a strong thread of sustainability, so that students graduate equipped to handle the challenges of our complex and interconnected world.

In the absence of the societal will to fund education adequately, we are well past the time when we need to be developing and implementing, at a large scale, radically different educational strategies that will provide the opportunity for quality and affordable education for the vast majority of students globally. Rather than wasting time continuing the apparently futile attempt to support our existing expensive educational infrastructure, it is time to begin planning for a time not long from now when educational resources are delivered almost entirely online, with students working individually or in small groups in a range of venues, when educators are largely remote facilitators of learning, where learning at the secondary and university levels have extensive project and service-based learning components, and where schools and universities become research, collaboration, and testing facilities available to local learners and educators, equipped with quality resources and capabilities, but not teaching staff.

### **WHAT ROLES SHOULD THE RESEARCH UNIVERSITY PLAY IN ADVANCING GLOBAL SUSTAINABILITY?**

Some of the papers in this volume focus on the role of research universities in advancing global sustainability in areas that are central to research universi-



ties today — namely undergraduate and graduate education, research and innovation. The recommendations presented here take the research university's role a step further — reaching out meaningfully to K-12 educators and community.

It is unfortunate that the pressing need to develop and implement globally sustainability systems arises at a time when resources are so severely limited, and education systems are under such stress. At the present time, leadership is desperately needed in advancing widespread sustainability education. With the paralysis that comes with difficult economic times and political gridlock, governmental decision-makers and program directors can find it impossible to move forward novel and well thought out programs due to a lack of financial resources and political pressures. Yet the clock is still ticking on our need to educate our youth on sustainability, and to develop the next generation of sustainability-enabled professionals. Some one — or some ones — must step up to help provide leadership in this vacuum. Research universities, as the home of the few who have had the opportunity for advanced education, are natural sources of the expertise we need to do research within and across disciplines with a focus on sustainability issues — helping to develop solutions to vexing interconnected problems. But precisely because of their specialized expertise, research universities should take their role several steps further.

Researchers developing promising approaches on sustainability issues should be encouraged to bridge the chasm between research and implementation, so that university-based innovation is more effectively moved out from the university research sector to the real world. While many research universities have excellent schools of education, in addition to their STEM departments, dysfunctional collaboration between science discipline departments and the schools of education is legendary at research universities. The reason for this is perhaps not surprising — education researchers are rewarded for research on innovations in pedagogy, typically tested at the small scale in individual classrooms, and reported in their research literature, similar to the motivations of scientists in their own disciplines. Neither has an explicit motivation to scale up innovative approaches that work on a large scale. For this reason, many exciting new approaches to learning are tested and documented, but never succeed at making it into widespread implementation. In the area of sustainability, we can't afford to lose lessons learned, as promising approaches to sustainability education are developed, and not implement the best of them at larger scales. As university faculty work on developing approaches to sustainability education, they should be encouraged to take these efforts a step further to ensure that their innovations are actually implemented in educational systems.

A major area of concern, considering the sad state of education today, is how to develop effective educational strategies that use technology for educa-

tion and reconfigure our approach to education. Research university faculty can make significant contributions here, working with educators, to develop and test new approaches, and then, once proven, work to implement these solutions at the large scale. Note that distance learning, as implemented today in K-12 and universities, leaves much to be desired. In order for the new paradigm shift mentioned above to be effective, online learning materials must become much more engaging, enable more meaningful faculty interactions, and be designed so that it is not possible to beat the system and defeat the learning objective.

There is another role for faculty at research universities that should be actively encouraged. Many university faculty have been accused of living in “Ivory Towers”, engaging little with their communities and, many times, not taking the time to describe their research within their communities. This lack of engagement can lead to a lack of trust between university faculty and the public, leading to negative consequences, such as we have recently seen in the area of climate change science. As researchers work on sustainability, it’s also important to engage actively in community, and develop trust there, so that when we share difficult messages, the larger community will have a basis upon which to trust — or at least not immediately discount — what we say.

Of course, all of this takes time from university faculty — some of it in areas of effort that are not traditionally valued in the university reward structure. If universities are serious that they want their faculty and students to become engaged in advancing sustainability, they must develop reward structures that meaningfully account for these efforts in ways equivalent with the traditional focus on publications, grants and teaching. Without a reward structure that places a reasonably equivalent value on these efforts, only a very small fraction of university faculty will chose to work in these areas.

The scope of effort needed for global sustainability education is vast and daunting — and it needs to ramp up in earnest soon. Some leadership is needed to facilitate, connect, and where possible, coordinate the activities of the many different organizations, researchers, and programs that are working to advance the sustainability agenda. A quick search on Google shows that there are many groups trying to make a difference in this area, working on different scales, and many dependent on transient grant funding. An internationally-based leadership organization could provide the essential glue that is needed to help the sustainability community advance with a semblance of organization and facilitate the leveraging of resources among groups so that all have the opportunity to advance more rapidly together, building on each other’s successes and programs.

Finally, we should all remember that the most essential element of a global sustainability solution is our youth. Whether in primary or secondary school, or in the university, our youth are the individuals who will need to create the

sustainable world of the future, and they have the greatest stake in that endeavour. Furthermore, they have enormous energy and motivation, and are comparatively inexpensive. In all of our sustainability activities, we should remember to engage youth as broadly as possible, taking advantage of their energy, their enthusiasm, their insights, and their facility at networking and communication to help rapidly advance the sustainability agenda.

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