Using Climate Change as a Teaching Tool

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Abstract

Climate change, like many other controversial issues, is an ideal pedagogical tool for encouraging a number of desirable outcomes in environmental education. It serves as an excellent context for teaching the science of complex systems, or chaos, as well as a wide variety of more traditional content. Chaos is a powerful paradigm for building understanding of how the world works. It also empowers students to take individual action on large, seemingly insurmountable problems. Climate change can help make learning relevant; it is the ideal arena for debating the merits and application of the precautionary principle, and for giving students the opportunity to find their own voice in a key public dialog of our time. This process develops a host of desirable learning goals, including problem solving and conflict resolution. Teaching climate change is also challenging. Educators must be flexible and allow, even encourage, a diversity of opinions. Assessment should to be driven by student success in performing specific tasks, rather than by arrival at a "correct" answer.

Résumé

Comme plusieurs autres enjeux controversés, le changement climatique est un outil pédagogique idéal pour favoriser de nombreux résultats souhaitables dans l'éducation environnementale. Ce phénomène fournit un contexte pour enseigner la science de systèmes complexes, ainsi qu'un large éventail de contenu plus traditionnel. Le chaos est un puissant paradigme pour engendrer une compréhension du fonctionnement du monde. Il habilite en outre les élèves à agir individuellement face à des problèmes d'envergure et, selon toute apparence, insurmontables. Le changement climatique peut aider à rendre l'apprentissage pertinent. C'est l'arène de choix pour débattre des mérites et de l'application du principe de précaution et pour donner aux élèves l'occasion de

s'exprimer dans un important dialogue public de notre temps. Ce processus crée toute une gamme de buts souhaitables pour l'apprentissage, dont la résolution de problèmes et de conflits. Les éducateurs doivent être souples et permettent, voire encourager, une diversité d'opinions. Il faut ensuite axer l'évaluation sur le succès des étudiants dans l'accomplissement de tâches particulières, plutôt que sur l'obtention d'une réponse « correcte ».

The issue of global warming is a perfect example of the clash between the worldview that most of us are exposed to in formal education and the complexities of the "real world." There appears to be a reluctance in some circles to bring current events of this nature into the classroom because they are complex, messy, and controversial. Scientific evidence is not conclusive, the consequences cannot be known with any certainty, and it is not always clear what the students can do individually or collectively to address the issue. Of all of these challenges, I feel the last is the most important. It is easy for environmental education to turn into a litany of woe and doom, to which students often become numb and apathetic in self-defense. There is a much better approach to teaching complex issues like climate change, one that can lead to profound growth for students.

Climate change is an ideal tool for introducing students to the science of complex systems. Complexity is not in many textbooks yet, but it should be. It is one of the most important concepts we must teach our students. Nearly every significant problem they will address in their private and work lives will be complex, messy, and involve conflicting data and uncertain consequences. In short, they will be dealing with complex systems. It doesn't matter if they are buying a house, choosing a mate, picking the best vendor for a product, or designing something. There are rarely clear guidelines for making these choices, the implications of any of the choices are never fully known, and there is always the potential for an apparently ideal solution to blow up in their face. By carefully examining the climate change issue and the progress of the debate over the last 15 years, students can begin to learn how real systems work or do not work. They can build on (or in some cases unlearn) the knowledge gained by studying the simple contrived systems most often used in education. They can learn some of the strategies that have been applied to the analysis of complex systems and to the policy debates that form our collective responses to the impact of these systems.

There are several specific content goals for studying the climate change issue. At the present time, most of these are not listed in the scope, sequence, or syllabus of many courses. Yet the importance of complex systems is slowly trickling into the public consciousness. Part of the role of education should be to hasten this process by giving students an understanding of the chaotic nature of nearly all real systems. A few examples of such systems include the economy (Day, 1982; Peters, 1991), brain activity (Garfinkel, 1983), an ecosystem (May, 1974, 1976, 1987; May & Oster, 1976), the solar system (Laskar, 1989; Sussman & Wisdom, 1992), and, of course, the atmosphere (Lorenz, 1963, 1976; Zeng, Pielke, & Eykholt, 1993). Here I am not using chaos in the general sense of crazy, wild, or messy. I mean chaos in the formal sense of a system that is highly sensitive to changes. In other words, it is a system with feedback, where one change induces other changes in a complex web that eventually leads to a condition in the system that is quite different from its original state. A classic example of this is the feedback that often occurs with public address systems. A sound, and it might be a tiny sound, is picked up by the microphone and sent through the system to be amplified and projected out through the speakers. This amplified sound is then picked up again by the microphone, amplified further, and projected to continue the cycle. The result is a high pitched, painful squeal that bears no obvious relationship to the original sound that caused it. That is chaos. That is how essentially the entire universe works. Small changes can have large consequences. These consequences are inherently unpredictable.

For many people the functioning of a chaotic system is counter-intuitive. There is a general feeling that the small things do not matter. A straw really cannot break a camel's back. That would require an entire bale. When dealing with the environment, it is the big polluters that are the real problem. Those "evil corporations" dwarf my individual impacts. What difference could a couple of quarts of oil dumped on the ground make? That extra car trip to the store is not going to matter compared to all the other carbon dioxide and pollutants already being emitted. Sentiments like these are essentially universal and are reinforced by books, movies, and numerous other venues of public discourse on the environment. An understanding of the sensitivity of complex systems and the importance of feedback teaches that nothing is insignificant, that everything we do and do not do has the potential for global consequences. This awareness requires us to confront our own behaviour. We are no longer permitted to excuse those actions of ours that fall short of our ideals. We cannot absolve ourselves by saying, "I'm just one person. What can I do?" This knowledge is also the most

important reason for teaching an issue like climate change, and will be discussed later.

A second outcome from studying complex systems is the awareness that the more intensely managed a system is, the more unstable it becomes. My favourite example for illustrating this is the movie *Jurassic Park* (1993). While it is fiction, it is familiar to most students and it is strikingly parallel to real systems and situations. The key theme of the movie is that the more control we try to exert over a complex system the more likely it is to take on a life of its own, thus creating a chain of events that we could never have predicted and are incapable of responding to effectively. The importance of understanding this principle is that, once again, it goes against conventional thinking. All environmental problems are created or, at least exacerbated, by human *hubris* that believes we have the knowledge and ability to manage the world and recreate it in our image. A typical classroom is another fine example of the folly of such thinking. No matter how hard one tries to manage children to sit quietly, walk in straight lines, and always do what they are told, the system has other plans and agendas. The harder we push for perfect behaviour as we define it, the more likely the end result is something entirely different. In my opinion, one of the most powerful gifts we can give our students in environmental education is this awareness: we will be better off as a species if we resume our place as part of the system in which we live, and give up the illusion of being lords and masters over it.

A third powerful reason for using real issues as a teaching tool is that they can make learning more relevant to students. One of the biggest barriers to student success in the classroom is lack of motivation predominantly caused by an apparent lack of relevance to the student. What students are learning just does not have anything to do with what they perceive as important. Global warming, on the other hand, has been addressed in all forms of media, including movies and novels, as well as the news and scientific press. It is even on the Web, which makes it "cool" by definition. I receive repeated comments from students in my introductory environmental studies course that they like the course so much because it is real and relevant. We discuss issues that are current, significant, and have an impact on their lives. I do not receive comments that the students are upset because the issues have no clear answers, or that I require the students to formulate and support their own opinions and action plans.

If one looks carefully at the prehistory of global climate and climate change (called paleoclimate), a vital and profound picture emerges. Climate has changed slowly over hundreds or thousands of years, but it also can change very rapidly and dramatically over timescales of a generation or less

(Alley et al., 1993, 1997, and references therein). These rapid changes are examples of a property of chaotic systems called bifurcation. A bifurcation is a rapid and dramatic change in the state or condition of a system. All complex systems have the potential to bifurcate. Essentially all predictions of future outcomes of human activities ignore the key role of bifurcation. Whether the issue is population, water use, agricultural production, or climate change, the future is always projected as a continuation of current trends. This assumption is usually explicitly stated by responsible prognosticators and, in most situations, there is probably little alternative but to make predictions based on current trends. However, it is seldom mentioned that current trends never continue indefinitely. Change is the overriding principle in all complex systems. Predictions for shortages of copper that were made in the 1970s did not materialize, in part, because of the impact of recycling, and because the introduction of fiber optic cables and wireless communication greatly reduced the demand for copper. This is an example of a bifurcation in our communication system. The current system bears little relationship to what existed before or to what was predicted by those whose thinking was locked in that former system.

There are numerous examples of other bifurcations that have impacted the environment. The important lesson from these examples is that great care must be taken in choosing our actions and in projecting future outcomes of current trends or activities. The world is a nonrepeatable system. We cannot choose a path to follow and, after a time, rewind and play events over again like a video tape to see which causes impacted which results. We cannot return to the fork in the road and pick another path if we do not like the results of previous choices. We have no practice runs, no do-overs. Since the world is nonrepeatable, it is impossible to know what chain of events might lead to a bifurcation. They cannot be predicted. The future is intrinsically unknowable. Furthermore, attempts to control or manipulate a complex system like the climate are likely to result in exactly the type of events illustrated in *Jurassic Park* (1993), a bifurcation to a new and unexpected form of the system. Even unintentional changes caused by our actions or inaction can yield the same result. It should be obvious that this knowledge can easily lead to a profound sense of powerlessness and apathy. There is another equally valid and infinitely more positive and productive way to use the potential of bifurcation in environmental education. These are outlined in the following two goals.

Any classroom discussion of climate change must include an introduction to the precautionary principle and its key role in developing our response to complex systems. Like most controversial issues the rhetoric

about global warming spans the entire spectrum, from "the earth will be destroyed" paranoia of the environmental doom and gloomers, on one hand, to "the economy will be destroyed if we change anything" of the economic doom and gloomers on the other. From past experience, most of us believe that neither outcome is likely to occur. A common response to this dichotomy is to do nothing until there is overwhelming evidence as to what the outcome actually will be. In other words, the status quo usually wins. The precautionary principle states that for high-stakes issues that involve the health and welfare of society or individuals, decisions should err on the side of caution (Tekner, Raffensperger, & Myers, 1999). Knowledge of the potential for bifurcation provides an especially strong motivation for caution. The precautionary principle asks us to question the true need for or value of a proposed action. It suggests that proof of the safety of a new technology, for example, ought to come before the technology is implemented, in contrast to the current practice of requiring absolute proof of harm from the affected group(s) after the technology is in place.

Students could become deeply engaged in this issue by debating the merits of the precautionary principle in the context of climate change. There are a number of questions that might be argued. For example:

- Do the facts suggest that human-induced climate change is real?
- How great is the risk?
- What are the possible repercussions?
- Are the risks significant enough that it is worth taking steps to address this issue even though there may be undesirable consequences to these actions (economic disruption, etc.)?
- What should these steps be and, more importantly, why?
- How could this plan be sold so that the opposition would buy into it?
- Is there a way to create a win-win situation where everyone gets something they value?

There is much empowerment for students in formulating their own answers to such questions. There is no tyranny of a correct answer in the back of the book. Nobody knows what will happen or what the correct response is. By respecting their answers and the process by which they arrived at them, a teacher shows respect for the abilities of the students and helps to build self-image and self-confidence. By teaching this process, a teacher helps students develop invaluable life skills such as critical thinking, creative problem solving, conflict resolution, prioritization, and many others valued in our educational system.

The final important lesson that can come from struggling with the issue of climate change is, in my view, the most important. As I mentioned earlier, it is easy for students to become overwhelmed by the negativism inherent in most environmental issues. It is easy to feel helpless and doomed, as if anything you do really will not matter. If teachers leave students to fend for themselves at this point, they have done a great disservice to the students and to the topic of study. Besides, it is entirely unnecessary. *Jurassic Park* (1993) illustrates how a seemingly insignificant event or a series of events can trigger a chain reaction that leads a system to collapse and destruction. However, the powerful message of complex systems is that other equally insignificant events can create a chain reaction that causes a bifurcation towards a more desirable form of the system. The example I like to use is that of Rosa Parks in Atlanta. When she refused to give up her bus seat to a white person, she did not single-handedly cause the Civil Rights Movement. She was a single, apparently insignificant individual whose single, small action kicked a highly-stressed complex system (American society) into bifurcation. This created a period of disruption, chaos (in the non-technical sense), pain, and destruction. In this case, however, the pain was the product of growth and the society that emerged is generally viewed to be a few incremental steps better than what existed before. This is the powerful message of hope inherent in complex systems. Anyone can be a Rosa Parks. Any student in the classroom might someday be in the right place at the right time to change the world by their choices and actions. This claim, though widely used already, only becomes believable when one understands the explosive growth potential of small disturbances in chaotic systems. You truly can be the straw that breaks the camel's back, for good or bad. This is true empowerment.

To teach climate change or similar issues successfully, teachers must be flexible enough to give up the need for a clear-cut agenda. As in all complex systems, teaching about the real world takes on a life of its own. Digressions are common. Outcomes are never the same from class to class or year to year. One has to be willing to focus more on the process than the outcome. This may appear contrary to many of the expectations put on teachers today, but that is precisely why it is so important. To quote W. B. Yeats "education is not the filling of a bucket, it is the lighting of a fire."

Teachers must also be willing to not know everything. They have to be able to say, "I don't know," because incertainties will arise. Digression is risky, in the sense that one does not know where it will go. It is also exciting for exactly the same reason. Successful teaching of complex issues requires that the latter view must prevail in one's heart. Similarly, when stu-

dents hold opinions different from the teachers, the teacher must be able to respect those opinions. This means that evaluation of learning must be based on the quality of the student's research, how well they formulated an opinion and supported it with quality facts. Again, the process is the focus. Teachers need to be able to give high marks to an argument that is completely at odds with their own beliefs, if it reflects quality work, and correspondingly low marks to a poor argument that mirrors their own views. This can be difficult, but it is important. Like all skills, it can be developed with effort and commitment.

Finally, teachers cannot see their role as primarily advocating for a particular position on climate change or other controversial issues. It is irresponsible not to present your opinion at some point (after all, you are requiring the students to do it), but it must be presented in a non-judgmental way that allows respect for dissent. Otherwise the whole purpose of teaching such issues is lost. I find myself using the phrase, "in my opinion" regularly. This will be insufficient if you believe and, hence, communicate (through body language and other unconscious ways) that your opinion is Truth. One must always be aware of the line that divides education and indoctrination. The latter is entirely antithetical to an open society, no matter how noble the goal.

The challenges and risks associated with teaching complex issues like climate change are decidedly non-trivial. Such topics can be perceived as interfering with important (even mandated) content goals. The reality is that most traditional content goals can be taught in a number of contexts. Climate change is a tremendously broad issue. There are endless possibilities for covering traditional content within the framework of such issues. The benefit is that all the additional outcomes outlined above are included when complex issues are used in this manner. Learning is not limited by time, but rather by connections. The more connections a teacher can guide students towards, the more powerful the learning. Climate change can be the context for creating such links. Our minds, like our brains, are complex systems. They are built on connections, on feedback, and more connections mean greater potential for explosive growth. I would append Yeat's earlier quote by saying, "education is not the filling of a bucket," it is the creation of bifurcations. Though profoundly less poetic, this is still a powerful model to envision.

Notes on Contributor

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