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Assuming Responsibility for the Anthropocene: Challenges and Opportunities in Education

Introduction

The Anthropocene is a scientific hypothesis based on the assumption that humanity has become a global Earth system factor in sectors such as water circulation, climate, biological productivity, biodiversity, geobiochemical cycles, sedimentation patterns, and overall use of lands and seas (Crutzen and Stoermer 2000; Crutzen 2002; Williams et al. 2011). If this hypothesis is correct, and all available data corroborate its correctness, it has a great range of implications.

It is necessary to understand that the previous epoch, the Holocene, has definitely come to an end and will not be reestablished ever. Our current social and economic systems, such as agriculture, permanent settlements, transport and trade infrastructures, and the large-scale division of labor, all developed during the relatively stable environmental conditions of the Holocene. Now, however, we have managed, inadvertently and unconsciously, to strain these same environmental conditions to their limits. Ethically, the Anthropocene emphasizes that all of us—from individuals to states to the United Nations—are collectively responsible for the future of the world. Conceivably, the same force that previously wrought unintended changes could be used in a conscious and reflected manner to create a world that is sustainable on a regional as well as global scale for many generations to come. As a conceptual framework, the Anthropocene could hence provide a solid basis for envisioning a sustainable human presence on Earth in which humans would no longer be “invaders” but rather participants in shaping the natural environment. In the future, technology and culture could be integrated into nature—and thus the “unnatural” environment that surrounds us today would be transformed into a human-designed neo-natural environment that includes culture and technology as an integral part of an interconnected system (Leinfelder et al. 2012).

Assuming such responsibility, however, means that transforming nature into even more human-made environments must be based on scientific knowledge and large-scale participation of society to find the possible pathways to a sustainable future. Efforts to shape a sustainable Anthropocene of tomorrow must also follow the precautionary principle: where there is a suspected risk of harm to humans or the environment, efforts should be made to reduce these risks even if there is not yet definitive scientific proof about the causes.

Given the fact that our scope for action is limited by our knowledge, and that there is no single one-size-fits-all path to a solution, societal and individual responsibility will be of paramount importance. Society will have to legitimize science and technology, focusing in particular on education as one of the most powerful tools for transformation, in order to make the Anthropocene long-lasting, equitable, and worth living. Boundaries between science and the education process will probably vanish, giving way to new transdisciplinary approaches, with science and society interacting in a great variety of new ways. In other words, education for the Anthropocene encompasses a great array of challenges as well as opportunities. This paper attempts to outline some of them and presents a couple of practical examples on the way towards a necessary reorganization of educational systems.

Understanding the State of the Planet—an Educational Challenge

Nearly everybody is aware of the fact that humans exert influence on Earth systems processes. However, almost no one is actually aware of the magnitude of these effects. Recent data illustrate how realistic the Anthropocene hypothesis actually is: about 77 percent of all (ice-free) land surface cannot be considered pristine; it is in use by humans or has been at one time. The world is no longer characterized by biomes, i.e., natural sets of habitats, such as wild forests, savannas, or shrublands, but rather by "anthromes," i.e., cultural landscapes, such as managed forest, cropland, pasturelands, and urban areas. About 90 percent of primary plant productivity happens in these anthromes. Pollen, one of the key elements that helps us characterize natural environments in the fossil record, is dominated by just a few cultivated plant species worldwide. Invasive organisms also alter future sediments, as will plastic particles and other human-processed matter. Fish populations are strongly overfished and partially collapsed. Our present extinction rate is assumed to be at least 100 times higher than during normal episodes of Earth history development. Atmospheric carbon dioxide has never been as high during the entire history of humans as it is now. More than 50 percent of all freshwater is managed by humanity. Nitrogen oxides and sulfur dioxide emissions are now higher than their natural counterparts, and the mean erosion rate is now up to 30 times higher than during the average of the last 500 million years. At the same time, dams filter out sediment load from rivers, causing deltas to retreat and local sea levels to rise, because the eroded material is no longer being redeposited (e.g. Crutzen 2002; Wilkinson 2005; Rockström et al. 2009; Williams et al. 2011). This list could easily be continued.

Understanding Systemic Interactions and Feedbacks in a One-World System

Education about environmental problems, when it occurs at all, usually presents them as discrete and isolated, often prioritizing certain problems over others. Is it more important to address climate change than biodiversity loss? Isn't food and water availability the primordial problem? Hence another educational challenge is to make the interconnectivity of processes and anthropogenic influence understandable. Just to give one example, many factors threaten biodiversity, not just activities that kill species directly, such as hunting, fishing, or pesticide use. Temperature and moisture changes associated with climate change may lead to habitat change and, eventually, habitat loss, which has a severe impact on biodiversity. Climate change also causes acidification in the oceans, again leading to biodiversity loss, for example, in coral reefs. Land-use change directly causes habitat loss but also has indirect effects: Using pristine land for agriculture may lead to overnutrification, which in turn may cause eutrophication of lakes and seas, that is, increasing amounts of nutrients such as nitrogen and phosphorus in the water, stimulating plant life and decreasing the oxygen content of the water, which in turn leads to biodiversity loss. And loss of forests, swamps, and organic rich soils due to land-use change causes loss of carbon sinks, again driving climate change, which in turn affects biodiversity.

While many people may be willing to accept the plausibility of the above examples, it is still more difficult to make clear that all activities in our sociospheres interact with the natural spheres and vice versa. Biodiversity changes and food production affect the natural spheres, but so does our entire economic system, our products and personal items, as well as our traffic systems, our science and cultural systems, ecosystems goods and services, our institutions, population, social organizations, and values and attitudes. Our entire existence depends on the natural spheres, but also substantially alters them. Making the industrial and societal metabolism better understandable is a key challenge that our educational systems have rarely tackled so far.

There are also many examples which demonstrate that simple and—at first sight—probably convincing solutions might not be systematically well thought-out. An example is liquid biofuels. The idea of drawing down carbon dioxide from the atmosphere into plants and then using these plants to produce fuels, which are then burnt, producing energy and releasing carbon dioxide back to the atmosphere, appears logical. However, this fails to take into account many negative external factors: competition between food crops and fuel crops drives food prices up, while land-use changes such as deforestation, fuel production, and transportation release additional atmospheric carbon. In addition, the efficiency of liquid biofuels is very poor in comparison with fossil fuels, and even worse when compared with solar or wind energy. Aquaculture of carnivorous fishes is another example. It does not diminish but rather stimulates overfishing, since the production of one ton of top-level predatory fish uses many tons of other fish for feeding. Other examples with potentially large-scale negative side effects might be solar radiation management or fracking technologies in conjunction with carbon capture and storage.

Understanding Time-Related Issues

The temporal aspects of the Anthropocene are a particular challenge for education. The "Great Acceleration" since the 1950s gives us an opportunity to compare acceleration processes in natural spheres (for example atmospheric gases, ocean structure changes, or ecosystem changes) with societal accelerations (for example increases in overall GDP, direct investments, river damming, fertilizer usage, urban population, paper consumption, fast food restaurants, or telephone sales). It is also very important to discuss different timescales and how they interact with each other, such as cosmic, evolutionary, cultural, technological, societal, and individual timescales. Tropical shallow-water coral reefs, for instance, have actually died out and recovered multiple times during Earth's history, but recovery required many million years. So at a societal timescale it is no comfort to think that disappearing modern coral reefs might recover in the distant future, given their great economic and recreational value now.

Different timescales may also overlap: the present anthropogenic changes of the natural system are occurring in the lifetime of a single generation but may often have geological-scale effects. This is particularly true of climate change, biodiversity loss, and production of nuclear waste. Probably the most difficult topic is learning how to handle statistical certainties and uncertainties. Geologists can predict very well where large earthquakes could happen in the future; however, they are unable to predict the exact days or even the year of a large quake. Environmental problems are similar: it is not possible to predict tipping points, such as destabilization of ice sheets, collapse of the coral reef ecosystems, changes in ocean circulation, shifts in monsoonal systems, or the occurrence of hurricanes and regional droughts, in a very exact way. However, statistical likelihoods will increase and may be well predicted. Learning to live with anthropogenically changed statistical likelihoods but at the same time accepting that the cause of a single event, such as a hurricane, cannot be denoted as natural *or* anthropogenic, is a difficult educational task. The importance of the 2° C limit for global temperature increase might be explained in this way and may be helpful for understanding statistical scenarios.

Given the necessity of substantial, worldwide, and systematic changes in the behavior of humanity, how will they happen? Politics alone will not be able to institute the changes necessary to create a sustainable society. Various climate conferences and UN conventions have had little effect, for the agreements are not binding and many nations refuse to follow them. The failure of these summits has led to discouragement and mistrust of politics. At the same time, non-governmental organizations (NGOs) and protest movements also have little chance to significantly alter society or the economy without the support of large portions of the population.

The Role of Education in a Social Contract for a Great Transformation

One proposal for how to create such a sustainable society is outlined in a report by the German Advisory Council on Global Change (WBGU). A "Great Transformation" will require that individual states and the global community facilitate transformative processes through top-down regulations, whereas NGOs, innovative thinkers, visionary companies, and societal movements will play a bottom-up role as pioneers of change. But this is not enough; the crucial element for creating wide-scale change is the existence of a societal transformation layer in which science, research, and technology work together with each other and the general public. This includes new dialogue and discursive formats, new forms of participation in politics and science, the development of best practice examples, platforms for forerunner companies, active involvement of dedicated public offices, the development of platforms for successful change agents, and finally ways of mainstreaming and routinizing these forms of dialogue (WBGU 2011, 2013). All this must be embedded in new forms of transformative and transdisciplinary education in order to allow the participation, discourse, reflection, and societal structures that are necessary for a transformation towards an Anthropocene that allows fair use and development chances for future generations. Such a knowledge-based transformation movement will therefore have to begin with new forms of education.

The 2011 WBGU report outlines several types of research and education required for accomplishing the Great Transformation. It distinguishes between "transformative" processes—that is, research and education directed towards finding concrete solutions to specific problems—and "transformation" processes—that is, research and education which focus on the larger contexts: how we have gotten where we are and what conditions are necessary for realizing the Great Transformation.

Transformative research and transformative education should support the active transformation process with specific innovations. Examples might be consumer research for new business models, developing more efficient technologies, and finding ways to distribute and encourage the use of new technological products. In other words, research in specific fields must be complemented by embedding it in the larger context. Transformative education must pick up this view and must cease to be treated as unidirectional knowledge transfer and instead be embedded in a culture of reflection and discussion. Transformation education, by contrast, focuses on factors and causal relations for transformation processes, on learning from history, as well as on the interaction between society, the Earth system, and technological development, and above all on human preconditions for change. It is especially this educational transformation aspect that the present article focuses on.

The structural challenges for an education towards societal fitness for designing a knowledge-based and livable Anthropocene can be summed up in one sentence: The world is a complex, fundamentally interconnected system, while research and education focus on individual subjects considered in isolation. In nearly all countries, schools and universities compartmentalize education to a large degree, and discussions are mostly about whether to cut down one subject in favor of extending another one, rather than about introducing transdisciplinary fields such as climate change, biodiversity change, or the Anthropocene. In principle, European university education should be particularly suited to developing inter- and transdisciplinary curricula, for example, by using the freedom promised by the Bologna Process to recombine educational modules or add cross-disciplinary modules to existing courses. In practice, however, there are no proper incentives to facilitate interdisciplinary careers. Many European countries are developing interdisciplinary summer schools, interdisciplinary centers, and even entire scientific institutions dedicated to global analyses and solutions through inter- and transdisciplinary research. However, such efforts must be increased, and a better funding and success-measuring incentive system must be instituted, as well as more fluid structures allowing for systemic research on transformation topics.

Systemic, integrated thinking deals with the entirety of a situation and, following Ossimitz (2000) encompasses four central key elements: (1) interconnected thinking, (2) time-lapse, "dynamic" thinking, (3) thinking in models, and (4) system-compatible action. Introducing cross-disciplinary, integrated thinking into school curricula is of paramount importance and has the potential to renew traditional educational thinking (Ossimitz 2000; cf. Leinfelder 2013b). Such systemic, transdisciplinary thinking will be essential for school, university, and professional education as well as for life-long learning, in order to not only understand the complexity of the ecospheric-anthropospheric system (as described in WBGU 1993), but also to reflect, suggest, and initiate possible integrative options for action. This is crucial if we want to establish awareness of local and global responsibility and to foster integrated thinking in order to arrive at a comprehensive understanding of options for transformative action. It is thus a prerequisite for making the theoretical concept of a social contract for sustainability, as discussed above, become a reality.

Educational psychology, and in particular the still-young field of environmental psychology clearly shows that cognitive, rational reflection alone is not enough for learning, especially complex learning, to occur. Motivation is the key element (e.g., Pelletier et al. 1998; Pintrich 2003; Gormley 2011), and this is difficult, because in today's society the Anthropocene must compete with the many other topics that clamor for our attention. Furthermore, there are no simple, easy solutions in the Anthropocene, and there may also be a sense of guilt for humans' role in creating the problem. As a result, it is particularly easy to make excuses or to choose comfortable arguments that relativize the problem, suggest that there is no urgency, or absolve the individual of personal responsibility.

In an ideal world, science and society should work together to produce knowledge and act upon it. The process would look something like the following: Researchers openly present their findings and explain the research process leading to these findings. They also candidly admit controversies and knowledge gaps. Then, scenarios based on the research findings are developed. They model future developments based on statistical likelihoods and assumptions about demographic development, the rate of technological innovation, and so forth. Using these models, options for actions are formulated. These can be suggested by special science-to-policy advisory bodies such as the WBGU, by citizens, or by politicians. Normally several options may be developed. Society, mostly in the form of political representatives, discusses the options and decides which options should be followed; the chosen option is then implemented.

However in the real world the process does not work this way. Often a great variety of personal motivations and economic and political interests stand in the way. These are often formulated as excuses.

- **The Relativization or Unreliability Excuse:** The presence of scientific controversy is interpreted as meaning that science is invalid and therefore preliminary research results can be ignored.

- **The Alarmism Excus**e: Critics choose to focus on particularly alarming scenarios and claim that such scenarios are exaggerated in order to support ulterior motives, such as receiving larger amounts of research funding.

- **The Missionary Excuse**: Using the reasoning above, possible solutions are dismissed out of hand based on claims that these actions are not necessary and that those proposing them actually just want to establish technocracies or eco-dictatorships, or brainwash society for their own purposes.

A more profound analysis of the arguments, strategies, motivations, and societal groups involved is beyond the scope of this paper, but it is important to note that motivations for science skepticism are not always driven by political or financial interests. Often, escapism and a desire to excuse oneself from responsibility may play a role. These attitudes may be encouraged by groups promising apparently simple solutions or arguing that there isn't a problem in the first place. In this respect, different kinds of science skeptics, such as evolution deniers and deniers of climate change or environmental change show similar traits. The problem is not so much these relatively small groups themselves, but their potential influence on rather large segments of society that may be driven to environmental skepticism because such a position is more comfortable than having to consider the "big picture" and the problems the world is facing, which would require changing one's own behavior. Other reasons for lack of personal involvement with environmental problems might include the belief that the effects of changing one's own behavior would be only minimal. Similarly, mistrust of others might lead to people choosing to continue to exploit, rather than preserve, common resources because they think others will act selfishly and take advantage of their altruistic behavior—the "Tragedy of the Commons." Finally, individuals might choose not to take any action because they are faced with multiple options and are unable to decide which one would be the best.

To sum up the "excuse game": three extreme and not at all science-based views of how the world of the future will develop are circulating, and they are not helpful for establishing individual and societal responsibility for taking care of an Anthropocenic world. These extreme, incompatible views are (in part following Zalasiewicz 2008):

- **The Trust-Future-Technology View**: Advances in technology will allow humans to completely engineer the planet, environment, and all living beings, essentially removing human society from natural cycles.

- **The Apocalyptic View**: We are well on the way to poisoning the entire planet and the ecological catastrophe is inevitable. Not only will organized society collapse, but all of humankind will probably die out in the near future.

- **The No-Problem View**: Human behavior is irrelevant because natural processes such as volcanoes and weather patterns are claimed to be stronger than any of the effects that human industry might have.

Not only are all of these views unrealistic and incorrect, but even worse, they are all fatalistic and therefore do not encourage action and change now. Even the first view allows rejection of present renewable energy technologies or present genetic engineering, because it appears better to wait for new technologies that would presumably cause less inconvenience for the individual; these might include proposals such as shading Earth in the atmosphere, creating artificial meat, or transporting all our nuclear and other waste to other planets.

How then, can people be motivated to make the changes necessary for the Great Transformation? One possibility is to look at how changes have happened in the past, both for inspiration that change is possible, as well as a source of models that may be applied to the present. This article will then highlight a number of projects currently underway to implement this societal transformation and encourage personal responsibilities and joint efforts, in part exemplified by projects with personal involvement of the author.

Learning from History

A very promising attempt to address the feeling that individuals and groups have of being overwhelmed by the magnitude of changes necessary for an Anthropocenic societal transformation is to highlight examples from the history of humankind that show ways in which long-lasting societal problems may be solved. According to the WBGU (2011), these lessons can be categorized into four types. First, *change by vision*, in which shifting values and ethical views lead to long-term alterations in society. These shifts may often be motivated by groups or individuals with visions of a better future, and gradually spread to the rest of society. The Enlightenment and abolition of slavery are possibly the best examples of how changing values and views, among other motivations, have resulted in one of the largest transformations of consciousness and society that we have ever had. Also important to state is that it took nearly the entire eighteenth century to implement Enlightenment, and that, astonishingly, abolition had not been a topic for the Enlightenment movement. Abolition took another 80 years, finally coming to a head during the secession war in the United States. The lessons from this are that change by vision is possible, that visions will have to be readjusted during the change process, and that implementation is a long and, in these examples, very violent pathway, with revolutions and wars taking place. Given the fact that it took nearly 180 years for the implementation of the vision of equality, liberty, and justice, the 20 years between the first Rio environmental summit and the relative failure of the Rio +20 summit is quite a short period, given the enormous increase in environmental literacy and activism that has already been achieved in many parts of the world. The vision of an integrated European Union is another example of where visions came first and implementation is still not completed (and is even, at present, faced with considerable challenges).

Crisis may also be a powerful motivation for transformation. *Change by crisis* is unfortunately one of the most common forms of change. Catastrophes such as drought, floods, or famines create an urgent need to develop new solutions to problems that may have been ignored until that time. In 1815 the gigantic eruption of the Indonesian volcano Tambora resulted in a global temperature drop: 1816, also known as "the year without summer," was marked by very poor harvests and a significant increase in livestock mortality, leading to the most severe famines of the nineteenth century in the northern hemisphere. In Germany, King Wilhelm I of Württemberg founded the Experimental and Academic Institute of Agriculture at Hohenheim in 1818 as a reaction to this; his goal was to "radically improve" the food supply using scientific methods. To this day, the institute is still entirely dedicated to agricultural issues. The Green Revolution that started in the 1960s is another example of worldwide change triggered by crisis, as are Structural Adjustment Programs for developing countries.

In rare cases, improvements of scientific knowledge may lead to change before a crisis occurs, such as when new scientific insights allow researchers to identify problems or side-effects of existing practices that had not previously been suspected. Unfortunately, *change by scientific knowledge* is far more infrequent than it should be, for it requires not only that the scientific knowledge exists, but that policymakers can be convinced to act upon this knowledge. And far too often, we discover the consequences of our actions after it is already too late to easily fix. The best example is probably the ozone hole, which was identified in the 1970s along with the cause, chlorofluorocarbons (CFCs). Chlorofluorocarbons had been developed for a very good purpose: replacing dangerous fluids and gases in items such as refrigerants and fire extinguishers with non-toxic and non-explosive inert material. The reactivity of CFC in the atmospheric ozone layer was initially not known; scientists Paul Crutzen, Mario Molina, and Frank Sherwood Rowland warned in 1974 that the ozone layer would shrink and holes might develop if the use of CFCs continued, research for which they later received the Nobel Prize. In consequence, CFCs were banned worldwide by the Montreal Protocol in 1987, in time to prevent the hole from growing to dangerous dimensions. Owing to the long "braking distance," the ozone hole is still not fully closed, but we are on the way to it. It is terrible to imagine what the consequences would have been if Paul Crutzen and his team had not discovered and loudly warned about the effects of CFCs!

Many other historical examples of societal or attitude change are a mixture of change by crisis and change by scientific knowledge. An example of this is the banning of DDT: although the scientific knowledge of the long-term effects of DDT was available earlier, it took Rachel Carson's book *Silent Spring* and her personal vision and action to highlight the dangerous effects of DDT on birds and other organisms and to initiate a movement against DDT.

Finally, technology is a trigger for transformations of all kinds, both positive and negative. *Change through technical innovation* is widespread and includes the mastery of fire and weapon-making in the Stone Age as well as agricultural methods for seeding, fertilizing, and watering that started in the Neolithic revolution. Another example is the perfection of the steam engine by James Watt in the nineteenth century, which was a key trigger for an avalanche of concurrent technical innovations and societal changes such as traffic and transportation, cloth and food production, and coal and iron mining and steel production. The IT revolution currently underway is another good example, with the spread of new communication systems even enabling revolutionary political changes, such as those presently occurring in Arab and North African countries.

It will probably require a combination of all these elements in order to bring about the changes needed for a long future of humans in a sustainable Anthropocene, with hopefully the crisis type not becoming the most important one. Science warns us that "braking distances" for many phenomena, such as climate change, rising sea levels, biodiversity loss, or contamination from nuclear waste, are of a geological timescale and not something that can be stopped or reversed within a few years.

Learning by Participation

Societal participation in research and the scientific monitoring of environmental or social change is crucial for teaching understanding of scientific procedures and scientific possibilities. This "citizen science" offers individuals insight into the challenges of the Anthropocene, as well as motivating personal action and change, producing individuals who then may serve as role models for others. Similarly, when options for action are being considered, citizen participation in the form of political and social discussion is needed to legitimize any decisions that are made. It is important to implement this early in people's lives, namely in school education (Eikel and de Haan 2007). Many polls and surveys indicate that individual and societal values are already fundamentally changing, but they also show the large gap between values and action, as well as the importance of factors such as worries about employment or economic growth for ranking priorities of values. Having the chance for discussion, discourse, reflection, and rethinking in participatory political processes or through new forms of more "liquid" democracies might be very helpful for achieving consensus on complicated issues such as the energy transition, transport systems, or land management.

Many best-practice examples exist. The Reef Check initiative (reefcheck.org) regularly assesses the state of coral reefs in a participatory manner, using data collected from around the world by volunteer scuba divers and reef scientists. Results are gathered in scientific databases, serve as the basis for scientific publications, and are an integral part of the survey reports of the Global Coral Reef Monitoring Network. These surveys are also a matter of debate for UN bodies. There are many other examples, mostly organized and performed by environmental NGOs, many of which focus largely on a specific species or ecosystem. Integrated and networked participative permanent anthrome monitoring stations on land are in a pilot phase. Schools, NGOs, natural history museums, other science institutions, and possibly public offices and companies could run such a monitoring network. Activities such as the early childhood science program Haus der kleinen Forscher, Junior Zoo University Berlin, or the youth science competition Jugend Forscht—all examples from Germany—should be further enlarged, networked, and funded. Traineeships and honorary lay researchers have become an integral part of personnel for science institutions such as natural history museums, and science slam and participative social media activities are growing. All have the potential to improve the integration of science into society. Programs for developing countries should also enlarge the amount of participatory activities, since motivation, knowledge generation, and science legitimization may derive directly from the participatory science process.

Experiencing Scenarios and Debating Pathways

While large portions of society may have a fair amount of faith in science and research, they may lack such faith when it comes to scenarios and options for action. It is psychologically plausible that simple line-and-curve scenarios, such as those provided by the Intergovernmental Panel on Climate Change (IPCC), appear "artificial" or demotivating. It is hypothesized here that developing more understandable and emotional scenarios that speak not just to our rationality, but to "brain, heart, and hands," might help to make scenarios and options for change understandable and easier to discuss. In order to avoid the (understandable) reaction that "it's not possible to predict the future, just look at past predictions for the future," a strong participatory element may be helpful in this process.

Museum exhibitions can tell stories and narratives from past scenarios; they may also help to make abstract scenarios of future developments more imaginable by offering visitors hands-on, participatory experiences. Scenarios based on different choices or actions could be developed by external groups, and museum visitors might then decide in a participatory way what they find most likely, most feasible, or most appealing. The planned exhibition on the Anthropocene at the Deutsches Museum, which will be produced in close cooperation with the Rachel Carson Center, was originally initiated by the present author and will experiment with such new formats. Other successful examples under the responsibility of the author were arts-to-science projects such as the living Anthropocene diorama and the HUM art festival, both at the Museum of Natural History in Berlin, or the participatory short film festival on the occasion of a UN biodiversity meeting in Bonn (see Leinfelder 2012 for more details). Current large projects include the Anthropocene Project at the House of World Cultures in Berlin, which contains reflective and discursive formats such as dialogue forums, performances, and festivals to open minds for the necessary fusion of nature, culture, and technology by reflecting on key questions such as "is the Anthropocene beautiful, is it fair, is it human?" The Haus der Zukunft ("House of the Future") planned by the German government in Berlin, as well as many currently developed relaunches of museums, including the upscaling of the Museum of Man and Nature in Munich, also address future-relevant topics and scenarios.

Pioneering: Starting the Change by Action

So far this paper has largely looked at the shortcomings, challenges, and requirements of an education enabling a societal transformation into a sustainable and long-lasting Anthropocene epoch. It has given some fundamentals, such as the role of participation, visualization, and new forms of reflection. This paper, however, should end with an appeal not to wait to transform education until top-down regulations have been changed, but rather to stimulate pioneering activities. Such change agents might be the only ones who can mainstream new and necessary developments, and by doing so also help politics to establish new frameworks and rules for educational transformation. I will briefly list some current activities that might fall into this category.

Integrated education across disciplinary boundaries

In a small research project we tested whether complex, Anthropocene-relevant topics such as the ozone hole, biodiversity issues, or even the Anthropocene concept itself can be taught under existing school curricula in an integrative manner (Poch 2012). We experimented with experimental modules bringing these topics in a concurrent, complementary fashion into school subjects such as chemistry, biology, physics, mathematics, geography, social studies, economics, and the arts. We checked with the official state of Berlin school curriculum for compatibility and evaluated the success through polls with students and teachers. Our findings were that such interdisciplinary teaching can already be implemented without incompatibilities with existing official school curricula, although new materials for supporting teachers would be highly welcome, and officially introducing a matrix curriculum structure that allows both traditional subject-specific teaching (vertical elements) cross-cut with transdisciplinary teaching (horizontal elements) would improve conditions for presenting complex topics.

Introducing integrative modules into university teaching

Similarly, at least in the majority of countries, university subjects are still largely taught in isolation, as pointed out above (WBGU 2011, chap. 8; Leinfelder 2011). Implementing new courses, interdisciplinary modules, or entire institutions in order to teach and research transformation and transformative issues requires substantial bureaucratic and structural changes that will take time; however, first steps may be taken even before such a transformation process is completed. The personal experience of the author is that many fields can already integrate key concepts of the Anthropocene into existing modules; for example, in geology, topics such as Earth history, geo-ecology, coral reefs, or ocean processes are highly relevant. Even field courses can be performed this way: an experimental course that I taught at the Freie Universität Berlin in 2012, “The Anthropocene of Berlin and Its Vicinity,” fusing geology, geography, and the cultural, social, and technical development of the region, turned out to be very successful. Similar joint projects are certainly possible in other subjects, such as biology, design studies, and the cultural, social, and political sciences. The German Advisory Council on Global Change (WBGU) has provided a free-of-charge online lecture video seminar on the Great Transformation that offers ideas for adding transformative and “Anthropocenic” elements to one’s own lectures (wit.va-bne.de).

Introducing new communication formats

Whereas the WBGU lecture series is designed for university teaching, another format has been developed by the author’s working group with the aim to “translate” the WBGU flagship advisory report on the Great Transformation to secondary schools and a still wider audience. The essentials of the reports have been converted into a comic book, with WBGU members being shown in their personal working environment and speaking—in speech bubbles, but in a normal language—about the challenges and solutions for the future of the planet, with a particular focus on climate and energy issues, although not limited to these concerns (Hamann et al. 2013). The comic book has received broad media interest and is part of a research project evaluating the potential of this format for communicating complex environmental and societal issues, as well as its potential for aiding transdisciplinary school teaching (Leinfelder 2013a; cf. die-grosse-transformation.de). The book tries to demonstrate that, apart from the need for new political and legal regulations and financing options, there are sufficient technical and societal options available for creating a sustainable future, both short-term and long-term; however, the most important factor is taking on personal responsibility and starting with personal action for change.

Personal everyday action

Personal action is certainly one of the most important forces driving a new education for the Anthropocene. Direct activities, such as upcycling fashion, car sharing, repair cafés, or urban gardening, to name but a few, can go along with making different lifestyle choices, such as changes in personal consumption patterns, e.g., choosing products with a long life cycles, following certification systems and ecological footprint indications, or not using plastic bags. Not only can this make a difference in energy and resource consumption, but it may also encourage others to follow one's own example, especially if individuals talk about their activities in social networks and blogs and among friends and local groups. Facebook or Twitter could be even models for how to rapidly spread and implement new ideas, making pioneering efforts into everyday routines. And why not experiment with new eating styles, such as trying insect food, algae, and so forth? Certainly, the new Anthropocene must also be sustained by positive actions of those who are willing to change in a creative, curious, playful, open-minded, and responsible way and inspire others to do so as well. Learning by doing might sound old-fashioned, but it is probably still the best way to start a Great Transformation to a long-lasting Anthropocene in which humanity and its actions are an integral and compatible part of nature.

Conclusion: Educational Ethics

Societal transformation towards a sustainable Anthropocene implies ethically relevant consequences for individual and societal thinking, lifestyles, and actions. All this must be based on available knowledge together with personal experience, reflected normative thinking, and personal well-being. Learning for the Anthropocene is therefore one of the most important prerequisites. Learning must be lifelong, creative, and motivating, as well as helping individuals to understand complex interconnected problems and preparing them for a world full of uncertainties and a lifestyle compatible with planetary and societal—hence Anthropocenic—boundaries. Such learning must be set up in a comprehensive and transdisciplinary fashion and must focus on acquiring practical, applicable knowledge and skills, rather than merely imparting facts. Personal perception of one's own and society's interdependence with the Earth system may be best achieved by participative learning and experimental model projects. The aim is also to encourage reflection about personal consumption behavior. Priorities and status symbols should be reconsidered. What does it mean to be "cool"? Can we learn where and under which constellations our "archaic reflexes"—aggression, selfishness, defense, or escape—tend to dominate? How much do social norms dominate our behavior? Why do we feel so comfortable in groups and often instinctively adopt the standards of these groups? How important are deviations from the mainstream? Do these lead to the formation of new groups? Can all this be reflected in one's personal curriculum and can it be used positively in terms of competence for sustainability? All new forms of education must tackle the question of whether and how we might reach a global ethos characterized by behavior patterns that are environmentally sustainable, fit for the future, and fair for future generations as well as our own. The ultimate aim would be to make understandable that each individual and each societal group determines the nature of globalization through their own actions. In this way, and with all the cultural and societal diversity we have on this planet, everyone is a member of a "glocal world society."

The Anthropocene concept appears particularly useful also for educational purposes, since it uses metaphors, integrates disciplinary knowledge, promotes integrative thinking, and focuses on the long-term perspective and with it our responsibility for the future. It thus includes broad ethical aspects that do not instrumentalize the Anthropocene for political motives but rather emphasize the open, pluralistic search process on the road to sustainability. This integrative, knowledge- and systems-based thinking is the only way to define essential ethically justifiable normative basics that may be summarized as follows:

The dualistic view of (good) nature opposing (an essentially "bad") humanity, including human culture and technology, cannot be further maintained in the face of the degree of anthropogenic influence on the Earth system. Humans must regard themselves as an integral part of today's (neo-)nature. Human economies and other activities must become compatible with nature, which implies that every individual thus automatically shares responsibility in this regard. Furthermore, the way back to the Holocene is neither possible nor ethically desirable. This implies that our behavior and action must be intra- and intergenerationally compatible. Finally, the path towards a sustainable Anthropocene is not an easy one, and it can only be followed by applying comprehensive and thoughtful integrative solutions. Knowledge-based sustainable "gardening" must supersede the prevailing overexploitation of nature; it should also form a reflexive basis for personal behavior.

Thus education for the Anthropocene has at its core an ecological humanity that emphasizes the freedom and dignity of the individual. Like scouts, every member of society is involved in the process of finding, trying out, discussing, and evaluating different paths towards a sustainable and long-lasting Anthropocene, thus assuming responsibility for this new and challenging geological epoch.

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