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The climate literacy challenge

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Abstract

Climate literacy is crucial for future low-carbon living. A key question is: who should be educated in the basis of climate science and what level of knowledge is appropriate for different ages of pupils? We designed a three years course for upper primary school in order to improve the climate literacy of the population. We have performed a three year testing of the improved curriculum at the pilot upper primary school. The curriculum was designed for grades 7 to 9 of the Czech educational system and can be modified for other countries.

Keywords: climate literacy; education; curriculum; lesson plans; science communication

1. Introduction

As a result of the exponential growth of human population, we are approaching several planetary limits or boundaries which threaten the environment. The behavior of individuals has been proved, in total, to have a huge impact on local and global ecosystems. Human activities are causing loss of biodiversity at a rate comparable to that of the last mass extinction. We have totally disrupted the nitrogen cycle by the massive use of fertilizers in agriculture. Another broken boundary of a safe operating space for humanity is climate disruption caused mainly by burning fossil fuels and deforestation (Rockström, 2009).

Anthropogenic global climate change is currently approaching tipping points where natural forces in the climate system react to cause further warming (Hansen, 2008). Economic processes such as the burning of fossil fuels are responsible for rising CO_2 concentrations in the atmosphere. Additional greenhouse gases retain infrared radiation and raise surface temperature of the Earth. There are only two realistic scenarios we need to consider for climate change analysis, (A) timely stabilization of temperature growth. Achieving this requires stabilization of CO_2

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emissions within a decade, followed by a gradual decline in CO_2 usage, (B) if the conditions for the fist scenario are not met, then excessive temperature increases rapidly become unstoppable (Meinshausen, 2009).

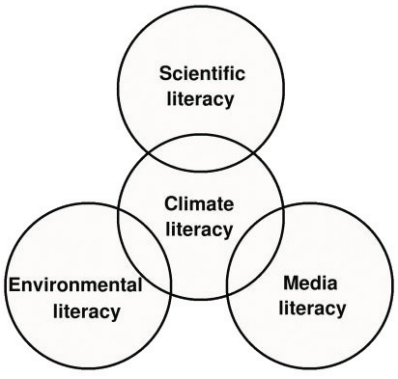
The future path is in the hands of today's decision makers. Very unfortunately, free trade does not regulate CO_2 emission. The world needs climate-literate leaders to make correct decisions and implement tough measures. Unfortunately such leaders are very scarce and progress is slow on the climate change treaty. Let's assume that we manage to reduce emissions and keep global temperature below the critical level. That would be a battle only partially won. And the goal of the next generations would still be to escape from the danger zone. Their lives would be carbon neutral or even carbon negative. Oil production is already reaching its peak and natural gas is predicted to peak within several decades. Vast reserves of coal are still underground. They must stay there if we want to stabilize the climate at Holocene conditions. People will have to learn how to live without oil and gas anyway, but they have to quit burning coal voluntarily. It is a duty of politicians to set the rules which can guide the world to a healthy, pleasant and earth-friendly low-carbon future.

The summer of 2003 was probably the hottest in Europe since at latest AD 1500. Over 40 000 Europeans died as a result of the heat wave. Following the climate change trends and scenarios Stott simulated that such extreme summer conditions will become normal in a mere thirty years. As these trends continue further, Europeans will experience even hotter summers by the 2060's and the temperatures of 2003 will be unusually low (Stott, 2004). This is a realistic scenario for the near future and it concerns toady's children. Educational systems all over the world ought to prepare the next generations for a very different world.

2. Climate literacy

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines literacy as "ability to identify, understand, interpret, create, communicate, compute and use printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals to develop their knowledge and potential and to participate fully in their community and wider society."

Literacy is also the necessary skills and knowledge we need in our daily lives. Not many people today have the ability to hunt, find edible roots or ignite fire with stones. These skills were replaced those developed to meet the challenges brought by more developed civilizations. Today we need to distinguish between functional literacy, ICT literacy, political literacy and many others. To some extent climate literacy overlaps with some of the slightly previously established "New Literacies." The topic of climate change appears frequently in the media but the scientific information is often misunderstood by journalists. That is why we need climate literacy for journalists and media literacy for the public.



Picture 1. – Schematic representation of interfering concerns of new literacies

Climate literacy is a brand new term and its meaning has not been defined and agreed upon worldwide. One of first attempts do define climate literacy was made in 2007 at a three-day workshop "Climate & Weather Literacy" at UCAR in Boulder. Groups of scientists and educators developed an initial framework for weather and climate

education. The outcome of this meeting is a document "Climate Literacy: Essential Principles and Fundamental Concepts" (NOAA, 2007). Their definition of climate literacy is stated in the box below.

"**Climate literacy** is an understanding the climate's influence on you and society and your influence on climate."

A climate literate person:

- Understands the essential principles of all aspects of the Earth system governing climate patterns.
- Knows how to gather information about climate and weather, and how to distinguish credible from non-credible scientific sources on the subject.
- Communicates about climate and climate change in a meaningful way.
- Makes scientifically informed and responsible decisions regarding climate.

We accept this definition and assume that it applies not only for the USA but for other regions as well. The workshop also suggested basic climate curriculum relevant to secondary schools. Our research concerning upper primary schools' climate curriculum is discussed further in this paper.

3. Climate literacy for all?

The key question is: "Do we need climate literacy for all?" If we look at the timescale, in the short term it is not a realistic objective to achieve. But, in long term at least, basic climate literacy for all is crucial. Although most politicians are climate illiterate they could be forced by the public to take appropriate action. Unfortunately both the politicians and the public have been manipulated by powerful lobbying by the oil and coal industry. Wide-spread denial of anthropogenic climate change competes with the data reported by climate scientists. Peer-reviewed articles are written in scientific language which is not easy to understand. The media tends toward sensationalism and often misrepresents scientific results.

Furthermore, it is doubtful that better awareness about climate change can spontaneously reform attitudes and behaviors of societies as a whole. Even with proper understanding and good faith people might fail to reduce their personal emissions. Our lives deeply depend on consumption of fossil fuels and reduction of carbon emissions is very difficult without radical changes in lifestyle. For instance, insulating buildings to reduce energy losses is surely a good idea. What would the family do with the money saved for the energy bill? If they use it to fly to holiday destinations, their carbon footprint rises again. Another good idea is to buy an efficient car. With low consumption of oil you would ride more often and carbon footprint does not improve. Do photovoltaic panels or wind turbines reduce CO_2 emission? There is no mechanism which would replace the power of coal plants by the power of renewable energy sources. Connecting new electricity generators to the grid without reducing coal plants only allows us to consume more energy. There are lots of examples of how we fail to reduce emissions even with bona fides. The most efficient political solution so far seems to be the implementation of a simple steadily rising carbon tax (Nordhaus, 2007). This carbon tax would gradually make fossil carbon too expensive and low-carbon technologies profitable. This approach could potentially work but it is a radical shift in the climate policy and the nowadays leaders have no courage to put it on the table.

There is a dilemma in how to achieve a change in climate policy. On one hand the politicians usually follow public opinion, thus the public has the power to force the politicians to take action. On the other hand the public is confused by media spin and climate education is a slow process and not very effective. Policies which do not match public opinion are not lasting. A concerned public should become the driving force of climate action.

We do need not only need better climate policy but also a change in the lifestyle of every individual. Paradoxically, good understanding of the climate crises can lead to apathy and resignation. It is a case of the famous British scientist James Lovelock who says it is too late to save the planet. Others, like James Hansen still haven't given up and have even boosted their efforts to mobilize people to action.

We suggest that effective climate education should be selective. It is better for the society to have one climate literate politician than one climate literate carpenter. Of course every individual has a the human right of climate literacy. But in the limited time we have, it is not a realistic goal to achieve climate literacy for all. Our approach seeks to select prestigious primary and secondary schools which are likely to recruit future decision makers,

managers of institutions and companies, journalists and teachers. These schools ought to be provided with programs of systematic climate education. If the society had climate literate leaders, journalists and teachers, the public would receive relevant information from them. All teachers should become climate literate at least at a basic level. First of all, we need programs to educate future teachers at faculties of education. Implementation of climate education at faculties of education requires close collaboration with the departments of Geography, Physics, Biology and others. These departments could provide courses for all students of pedagogy.

4. Climate education

Climate education can be formal (schools) and informal (media, museums, libraries, zoos). Informal education has the power to engage people of all ages and can achieve quick responses. Formal education engages a mostly young generation, which is important for the future development of society. In our research we deal with formal education only.

British communications organization Futerra has experience with communicating climate change through public lectures given all around the world. Futerra developed guidelines for climate change communication based on market research. They suggest that climate communicators should engage the public to action with a vision of an attractive low-carbon future. Of the role of education the say: "Climate literacy and education are the right options, but perhaps are not the most effective ones. We wish that understanding climate change would automatically lead to life styles changes. But it does not." (Futerra, 1996).

In 2008 the European Parliament and the European Commission ordered a survey named "Europeans' attitudes towards climate change". The survey discovered that respondents who feel informed about climate change take much more action to combat climate change than those who feel poorly informed. As an important reason for not taking action against climate change respondents mentioned lacking information. One of the specific questions was to decide whether they agree with the following statement: "Emission of CO_2 has only a marginal impact on climate change." Majority (55 %) disagreed, 30 % agreed, and 15 % did not know. This means that almost half of Europeans are not convinced that CO_2 causes harm to the climate. Why should they care about reducing their carbon emissions? We assume that climate literacy is crucial. Without climate education climate disruption is unavoidable. Even if humanity fails to stabilize climate, climate literacy will be urgently needed for adaptation.

Another study named "American's knowledge of climate change" involving 2,030 American adults was carried out by Yale University. The study was published in 2010. The last of 55 items questions concerned attitudes towards education. People were asked whether they agree or disagree with the following statement: "Schools should teach our children about the causes, consequences, and potential solutions to global warming." Results are following: 35 % strongly agree, 40 % somewhat agree, 14 % somewhat disagree, 11 % strongly disagree (Leiserowitz, 2010). In other words, three quarters of Americans favor formal climate education, which is quite an encouraging result.

5. Climate curriculum

Our study seeks to develop a climate education course which could be easily accepted by the current educational system. We analyzed the current curricula of the upper primary education in the Czech republic and suggested an introduction of a new climate curriculum. We have performed a three years testing of the curriculum at the pilot upper primary school. In developing the climate curriculum we considered the age of pupils, their mental development, their natural interests, and the structure of current curricula of traditional learning subjects. After testing various topics, classroom activities and lesson plans we suggested a climate curriculum which has a potential to achieve better climate literacy for future generations. The curriculum is consistent and has a logical structure. The topics correspond with conventional subjects and are appropriate for the mental level of the pupils. The curriculum was designed for grades 7 to 9 of the Czech educational system and can be modified for other countries.

There is no integrated science in the Czech primary education system. We have the subjects of Physics, Geography and Natural history from grades 6 to 9 and Chemistry from grades 8 to 9. Some of the topics taught in these subjects relate to our suggested climate curriculum. The Czech educational system implemented a new Framework Education Program in 2007. This document sets compulsory curricula for all primary schools. Schools are allowed to organize the curricula according to their individual needs. Most of the schools follow a structure of textbooks available on the market.

Subjects	Grade 6	Grade 7	Grade 8	Grade 9
Physics	Physical values and units, Measurements	Graphs, Motion, Atmosphere, Meteorology	Change of state, Energy, Heat	Astronomy, Nuclear energy
Geography	Planet Earth, Maps, People on Earth	Continents, Oceans, Climate, Biomes, Climographs	Europe, Czech republic	Globalization, Limitations of energy sources, Agriculture, Biodiversity loss, Climate change
Natural history	Planet Earth, Life on Earth, Ecosystems, Environmental protection	Zoology, Botany	Mammals, Human evolution	Geology, Blue planet, Natural resources
Chemistry	--	--	Air, Water, Carbon and hydrocarbons	Photosynthesis, Fuels

Table. 1. Some of the topics related to Earth sciences taught at Czech upper primary schools

Current upper primary curricula are well structured and contain a lot of information about Earth system components. Why does not such education lead to climate literacy? Unfortunately pupils are not able to connect the dots. They have good bricks but do not know how to build. Pupils need guidelines. Educators should not show them final knowledge explicitly but let them to discover themselves. Memorizing given facts can be good for writing tests successfully but does not improve attitudes. Pupils of grade 6 usually have heard about climate change from media. They have common misconceptions and sometimes even reproduce irrelevant arguments of deniers.

During a lesson of climate education we can explain how losing Arctic sea ice causes a positive feedback in Earth's energy balance. Shrinking ice reflects less sun radiation and more energy is absorbed by ocean. Warmer water melts more ice and so on. From our experience it is more efficient to let pupils to discover the phenomena themselves. We give our pupils pictures of Arctic sea ice extend throughout time since 1978 and let them measure the area covered by ice and plot a graph. They calculate average yearly loss of ice and compare it to an area of their country. In the next lesson they compare speed of melting ice cube in a glass of cold and warm water. If the school has a luxmeter available pupils can measure albedo of different surfaces. Now they are ready to analyze their observations and measurements. Teacher assists pupils with their work and helps them to come up with the conclusion. This kind of work is fun for the children and they easily accept what they discovered. Disadvantage of this approach is that preparations and lessons take more time compare to traditional teaching.

UNESCO recommends integrating climate change education into existing subject areas such as science, citizenship education, geography human rights education, and language courses (UNESCO, 2010). Traditional subjects have limited number of lessons per week and compulsory curricula cannot be reduced. Climate education can be performed during these lessons but it requires agreement and very good collaboration of several teachers. We prefer to have a special subject dedicated to climate education. Apart of traditional subjects Framework Education Program sets six cross-curricular subjects: 1. Moral character and social education, 2. Civic education for democracy, 3. Education towards thinking in European and global contexts, 4. Multicultural education, 5. Environmental education, 6. Media education. Some schools teach these topics as part of traditional subjects. Schools can also open a class dedicated to Environmental education, Media education etc. This is an opportunity to provide primary schools with climate education curriculum, methodology and lesson plans. Even without changes in official curricular documents we can perform formal climate education in the Czech Republic today.

We designed our climate curriculum as systematic three year course. The curriculum was tested at pilot upper primary school as a voluntary subject with time allotment one hour a week. A brief description of the curriculum follows:

Starting climate education at grade 7 is appropriate because one year before pupils already learned about physical values and units in their Physics lessons and basics of Earth science in Geography and Natural Science lessons. Main theme of first year of climate education is “Weather” dealing with meteorology and hydrology. Pupils learn

about physical properties of the atmosphere, analyzing data and plotting graphs. Pupils are responsible for taking daily measurements in the school meteorological station. Meteorological measurements are utilized in climatology which is a theme of the following year of the course.

At grade 8 we provide climate lessons where pupils can apply what they learned year before. They learn how to draw a climograph using mean monthly temperature and precipitation data. We perform several activities dealing with meteorological data because confusing climate and weather is one of the most common misconceptions. Pupils also learn about geological history of the Earth and key role of CO_2 during past climate changes and mass extinctions. They learn how people can find out a lot about past climate from geological records. One of the most important topics is learning about how media works and how to get scientifically relevant information about climate change progress.

At grade 9 pupils are mentally developed and able to integrate their knowledge of natural and social sciences. They already have enough knowledge about weather and climate. The following main theme of climate education is "Carbon cycle". Final topic of climate education ought to be mitigation and adaptation measures. Climate change mitigation is acting on a climate system in order to decrease the intensity of radiative forcing and to reduce the potential effect of climate change. Adaptation is an action to tolerate the effect of climate change. Some measures can be classified as both, mitigation and adaptation. For instance planting trees helps to remove CO_2 from the atmosphere and reduce greenhouse effect. At the same time trees can provide shade for people and animals store water and prevent soil erosion which are good effects to tolerate weather extremes. Our climate curriculum focuses on climate change mitigation and adaptation within third year of the course.

	Grade 7	**Grade 8**	**Grade 9**
Theme	Weather	Climate	Carbon cycle
Topics	atmosphere, weather lore, temperature, precipitation, clouds, humidity, pressure, water cycle	climographs, biomes, tropical cyclones, cryosphere, greenhouse effect, climate change, paleoclimate, mass extinctions, climate change in media	properties and forms of carbon, fossil fuels, biomass, energy sources, peak oil, carbon sequestration, carbon footprint, international agreements on climate change, climate change mitigation and adaptation

Table 2. Structure of the climate curriculum designed for formal education at upper primary schools

6. Conclusions

Education has always lagged behind development of society due to inertia in educational system. With a boom of personal computers educational systems had to deal with ICT literacy and its incorporation has been successful. Educational system could not be prepared for appearance of information technologies but was able to adapt. With climate change it is a different situation. Needs of future generations can be predicted following scientific studies concerning climate change. There is a growing gap between what is known about climate change by the scientific community and what is understood by the public. There is an urgent need to enhance climate literacy which is currently critically low as proved by several surveys. We assume that efforts towards climate literacy should be intensified.

We designed a three year course for upper primary school on order to improve the climate literacy of the population. After testing various topics, classroom activities and lesson plans we suggested a curriculum which has a potential to achieve the better climate literacy for the future generations. Whether formal education using our climate curriculum actually improves pupils understanding of climate science has not been tested. We completed the structure of the three year course recently and testing of efficiency is going to be another step. At our research we focused on the communicated knowledge but pupil's skills and value orientation have also a high importance and should be investigated in future research.

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