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THE USE OF COOPERATIVE LEARNING IN DISPELLING STUDENT MISCONCEPTIONS ON CLIMATE CHANGE

Evangelos Manolas,
Walter Leal Filho

Abstract. *Misconceptions may be characterized as wrong or inaccurate views of a particular issue which, due to lack of clarity, are seen or perceived wrongly. Students hold misconceptions about many issues and subjects, including in respect of climate change. Most alarming about misconceptions is that if people continue to build knowledge on such misunderstandings, this may have serious impacts on their learning. Following a brief literature review on cooperative learning, this paper adopts a research methodology which a) defines what a misconception is, b) lists possible sources of misconceptions, c) discusses five misconceptions students often have about climate change and d) puts forward some cooperative learning techniques teachers can use to handle the problem.*

Key words: *climate change, cooperative learning, education, misconceptions, students.*

Evangelos Manolas
Democritus University of Thrace, Greece
Walter Leal Filho
Hamburg University of Applied Sciences, Germany

Introduction

There can be little doubt that climate change currently is and will continue to be a matter of great international concern, with many economic, social and political implications (Leal Filho, 2011). Indeed, due to the scope of the problem, it is possibly one of the central challenges to the humankind in modern times, one which today's students will also need to face during their life time. The students of today will be the adults of tomorrow. They will face the future impacts of climate change and need to know today how to prevent an exacerbation of the problem and, as importantly, how to adapt to a changing environment.

As a complex issue that relates to a problem with different roots and many ramifications, climate change requires students to exercise skills such as understanding, thinking, researching, and criticizing. Also, as climate change is an interdisciplinary issue, teaching about climate change offers an opportunity to integrate several disciplines such as biology, geography, chemistry, physics and many more. E.g., students can learn:

- about the natural greenhouse effect;
- the steps scientists need take to measure and to understand changes in natural systems;
- how research information is developed into scientific models to predict changes that may occur in the future;
- how the predicted changes may affect not only the fauna and flora but also our society;
- how our behaviour influences climate change;
- what potential actions we need to take to adapt to the impacts of climate change;
- how climate change affects natural resources, particularly in the areas of agriculture, forestry, fisheries and water supply;

- how international politics affects adopting decisions to address climate change;
- how the mass media of communication represent (or misrepresent) these issues to the public.

Lectures are still the predominant mode of instruction at institutions of higher education. However, simply telling students what their misconceptions are does not necessarily help to improve their understanding. Misconceptions are a serious impediment to action against climate change at both individual and societal level. As Macionis (1997) has said "It's not what we don't know that gets us into trouble as much as the things we *do* know that just aren't so". To assist students in correcting their misconceptions, teachers should provide them with a wide range of opportunities to test their knowledge and to discover that –at times- what they seem or believe to know fails to be in line with reality (thanks to misconceptions) or to generate correct answers.

Following a brief literature review on cooperative learning (including a brief review on the usefulness of cooperative learning to combat misconceptions) this paper defines what a misconception is, lists possible sources of misconceptions, discusses five misconceptions students often have about climate change and puts forward some cooperative learning techniques teachers can use to combat the problem. Its innovative feature is that it offers new insights onto a subject which is central to the curriculum and can provide key support to overall environmental learning.

What is Cooperative Learning?

Active learning is anything students do in a classroom other than simply listening to a lecture. This includes everything from simple practices such as one minute papers to complex group activities such as debates or role playing.

The term cooperative learning covers the subset of active learning activities, in which students work together in small groups in order to achieve a specific goal. Cooperative learning entails:

i. Team work with/among students.
ii. Mutual opportunities for understanding and exchange of experiences.
iii. A sense of group where learning contents and learning experiences are exchanged among participants.

Cooperative learning is not the same as collaborative learning: "It is more directive than a collaborative system of governance and closely controlled by the teacher. While there are many mechanisms for group analysis and introspection, the fundamental approach is teacher centred, whereas collaborative learning is more student centred" (Panitz, 1996).

Why Cooperative Learning Activities?

The use of cooperative learning techniques in classroom is vital because of their powerful impact upon students' learning. Those who employ cooperative learning methods do so with a number of key assumptions in mind. According to Johnson, Johnson and Smith (1991), Lenning and Ebbers (1999), Matthews, Cooper, Davidson and Hawkes (1995), Millis and Cottell (1998), some of these key assumptions are:

- Learning in an active mode, e.g. in a small group, is more effective than passively receiving information, e.g. in a lecture setting.
- Participation in small group activities develops higher order thinking skills and enhances the ability to use knowledge.
- Accepting responsibility for learning as an individual and as a member of a group enhances intellectual development.
- Articulating one's ideas in a small group setting enhances student's ability to reflect on his/

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her own assumptions and thought processes.
- Developing social and team skills through the give-and-take of consensus building is a fundamental part of liberal education.
- Appreciating diversity is essential for the survival of a multicultural democracy.
- Teaching and learning can be a shared experience between teachers and students.
- Teachers may be effective as facilitators of learning. That is, they can promote learning by being a "guide on the side", rather than a "sage on the stage".

One further element, which speaks for the use of cooperative learning is that the insights and perspectives from students – no matter what background they have - are brought to full use and may help in the learning process.

With regard to the usefulness of cooperative learning in combating student misconceptions on science related issues, recent studies indicate that cooperative learning is superior to traditional teaching methods (Cunningham and Wescott, 2009; Boyes, Stanisstreet and Yongling, 2008; Acar and Tarhan, 2007; Acar and Tarhan 2008; Akınoğlu and Tandoğan, 2007). Recent research also indicates that in order to combat student misconceptions, we should give them the opportunity to identify them (Bishop and Anderson, 1990; Wescott and Cunningham, 2005; Anderson, Fisher and Norman, 2002; Lederman, Abd-El-Khalick, Bell and Schwartz, 2002) and then use appropriate teaching methods to encourage students to engage, explore, explain, elaborate, and evaluate their conceptions (Firenze, 1997). An teacher-centered approach, i.e., lecture, does not usually help most students recognize their misconceptions. In addition, according to Barke, Hazari and Yidbarek (2009), only when students recognize that their ideas are mistaken, and realize that their knowledge does not lead them anywhere, will they accept new information and thereby build up new cognitive structures.

According to Garfield (1993) and Allen, Duch and Groh (1996) the characteristic features of good cooperative learning activities are:

- They require that all members of the group be involved, and not just one or two students while the others are passive observers.
- They are open-ended, challenging students to justify the answers they give.
- They engender controversy or require decisions, so that students demonstrate higher order thinking such as synthesis and evaluation.
- They are complex enough, so that students working in groups can learn from each other and maximize their learning.
- They are assessed, so that students receive feedback and learn from any mistakes made.

In cooperative learning students are actively involved in the learning processes. They hear, see, exchange views and act. Generally, in contrast to passive methods of teaching, involvement with cooperative learning methods requires more serious preparation and more effort by both teachers and students.

Cooperative learning methods address learning style differences among students by providing different modalities on how learning can occur. Also, students serve as models of improvement for one another while, at the same time such involvement increases each student's confidence regarding learning in both the cognitive and affective domains (Leal Filho, Pace and Manolas, 2010). Given the complexity of climate change, use of cooperative learning might foster a better understanding of the issue.

What are Misconceptions and What are Their Sources?

Most people who hold misconceptions are not aware that their ideas are incorrect (Manolas, 2006). When they are simply told they are wrong, they often have a hard time giving up their misconceptions – especially if they have had a misconception for a long time. What is especially concerning about misconceptions is that if people continue to build knowledge on such misunderstandings, this can have serious impacts on their learning and may affect the students' ability to solve problems or apply their knowledge (in or out of class).

There are various definitions of misconceptions. A misconception may be defined as:

- an idea about or an explanation for a phenomenon that is not accurately supported by accepted physical principles (American Heritage Dictionary, 2000);
- a mistaken thought, idea, or notion; a misunderstanding (The Free Dictionary, 2009);
- preconceived notions, non-scientific beliefs, naive theories, mixed conceptions, or conceptual misunderstandings; something a person knows and believes but does not match what is known to be scientifically correct (Science Misconceptions, 2009);
- erroneous conception; false opinion; wrong understanding (Webster's Online Dictionary, 2009);
- a form of incomplete reasoning, leading to wrong answers because the conditions-under-which are not specified; or leading to right answers for the wrong reasons; or if right, failing in their limited, local application to embrace reality in wider contexts (Goldsmid and Wilson, 1980).

Some of the main sources of student misconceptions are:

- From the use of everyday language (Gilbert, Osborne and Fensham, 1982; Leach and Scott, 2003).
- From everyday experience and observation (Strauss, 1981; Viennot, 1979).
- From the use of perceptual thinking, which is related to the previous source, and is seen in a number of studies where students' explanations of scientific phenomena are dominated by what is immediately perceptible (Driver, 1985; BouJaoude, 1991).
- From diagrams or statements in textbooks (Blosser, 1987; Cho, Kahle and Nordland, 1985).
- From memorization of ideas (Stepans, 1994).
- From the interaction with teachers (Osborne and Cosgrove, 1983; Bar and Travis, 1991; Gilbert and Zylberstajn, 1985; Kruger and Summers, 1995).

Misconceptions may be a serious obstacle to true learning because they hinder the development of new knowledge. True learning is a cumulative process where new knowledge is added to prior knowledge (Ausebel, 1963). Students process information provided to them on the basis of existing cognitive structures. Teachers must recognize and help students correct their misconceptions and such a task may best be achieved through effective educational strategies (Taber and Watts, 1997; Frederick, 2000). A study of misconceptions in sustainability (Leal Filho, 2000) identified the fact that, even among senior academics, they do exist and hinder progress.

Students may resist new information that contradicts what they already think and believe, they may accept the new information and correct their previously held conceptions, or they may accept and memorize it in order to please the teacher and earn higher marks (Mulford and Robinson, 2002). Thus, misconceptions can be present both before and after the use of appropriate instructional strategies (Taber and Watts, 1997).

In order to help students challenge their misconceptions, the teacher should give students time to recognize their preconceptions, compare and contrast their ideas against those of others as well as assess differences in those ideas. Thus, students need to be actively engaged in the learning process (McKeachie, 2001). What is also of paramount importance for students to change their preconceptions is the discovery of concrete and unquestionable evidence. Such new evidence in combination with the discovery and use of previously held ideas is fundamental in helping students move to true learning (Ozmen, 2004).

As seen from the above, wide range of causes of misconceptions make attempts to address them especially difficult. This task is nonetheless very important and this paper now suggests some cooperative learning techniques that can be used by teachers, both inside and outside the classroom.

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A Teaching Technique

Before class:

Teacher copies the student handout "Climate Change True-False Quiz" for distribution in the classroom.

During class, part A:

- The teacher introduces the lesson by explaining to students that they will be studying climate change with the aim of finding out what they already know about the topic.
- The teacher administers the quiz. Before collecting the student papers, he / she reads through each statement and records true and false responses. No information is given to the students on what the correct answers are or the reasons why.

During class, part B:

- After a lecture on climate change the teacher re-administers the quiz. The original quiz sheets are returned to the students and students are asked to examine their answers and change any they no longer feel are correct.
- Students form pairs and compare answers. If both students of each pair agree, they should put both names on both papers and be ready to defend their opinion. If they disagree, they may use class notes and other references to reach consensus. Once all answers on both papers are the same, they should put both names on both papers and be ready to defend their opinion.
- Again, before collecting the student papers, the teacher reads through each statement and records true and false responses. This time the teacher provides students with information on the correct answers accompanied with an explanation. The answers given in the first quiz are compared with those in the second quiz. Students are then asked to describe what helped them to dispel some of their misconceptions (Energy Misconceptions, 2009).

Misconception Analysis

The misconceptions were selected because they capture the essence of the problem, the most important aspects of global climate change. The misconceptions selected are those which are used most often by those who deny the existence of the problem. They all emphasize the responsibility humans have in creating and addressing climate change and they all point to the magnitude of the threat climate change poses to the planet. Of course, many more misconceptions have been identified and no doubt more will. Indeed, interested teachers should build a list of climate change misconceptions for use in their courses. Both the misconceptions and the debunking of each misconception should be used as tools in guiding the teacher in scientific knowledge on climate change for the lessons.

Misconception 1: The Climate is Changing Due to Natural Variability Rather than Human Activity

In November 2007, the IPCC released the AR4 Synthesis Report, strengthening its views about the influence of human activity on climate change. The report states that:

> Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. I*t is extremely unlikely (<5%) that the global pattern of warming during the past half century can be explained without external forcing* (i.e., it is inconsistent with being the result of internal variability), and very unlikely that it is due to known natural external causes alone. The warming occurred in both the ocean and the atmosphere and took place at a time when natural external forcing factors would likely have produced cooling. From new estimates of the combined anthropogenic forcing due to greenhouse gases, aerosols, and land surface changes, it is *extremely likely* that human activities have exerted a substantial net warming influence on climate since 1750 (Attribution of recent climate change, 2011).

If current trends in GHG emissions growth are not altered, global temperatures are expected to rise between 1.4 and 5.8° C (2.5 to 10.4° F) by 2100 (Human Development Report 2007/08).

The US Environmental Protection Agency (EPA) discussed the human contribution to climate change in the following passage posted to its website:

> Careful measurements have confirmed that greenhouse gas emissions are increasing and that human activities (principally, the burning of fossil fuels and changes in land use) are the primary cause. Human activities have caused the atmospheric concentrations of carbon dioxide and methane to be higher today than at any point during the last 650,000 years. Scientists agree it is very likely that most of the global average warming since the mid-20th century is due to human-induced increases in greenhouse gases, rather than to natural causes...
>
> Natural variations within the Earth's climate system can cause small changes over decades to centuries... However, while natural variations have altered the climate significantly in the past, it is very unlikely that the changes in climate observed since the mid-20th century can be explained by natural processes alone (Are humans substantially responsible for global climate change today? 2010).

Misconception 2: Climate Change is a Deeply Contested Issue among Scientists

Absence of substantive disagreement in the scientific community about the reality of anthropogenic climate change is continuously and unequivocally stated not only by the IPCC but also by respected scientific bodies such as the American Association for the Advancement of Science (AAAS) (AAAS Board Statement on Climate Change, 2006), the European Science Foundation (Impacts of Climate Change on the European Marine and Coastal Environment - Ecosystems Approach, 2007), the European Federation of Geologists (Position Paper, Carbon Capture and Geological Storage, 2008), the Geological Society of London (Climate change: evidence from the geological record, 2010) and indeed the national science academies of the G8 +5 nations (G8+5 Academies' joint statement: Climate change and the transformation of energy technologies for a low carbon future, 2009). All these bodies stress that scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action, and explicitly endorsed the IPCC consensus.

Additional proof regarding the consensus among scientists on anthropogenic climate change is the analysis of 928 abstracts, published in peer-reviewed scientific journals between 1993 and 2003, and listed in the ISI database with the keywords "climate change":

> The 928 papers were divided into six categories: explicit endorsement of the consensus position, evaluation of impacts, mitigation proposals, methods, paleoclimate analysis, and rejection of the consensus position. Of all the papers, 75 percent fell into the first three categories, either explicitly or implicitly accepting the consensus view; 25 percent dealt with methods or paleoclimate, taking no position on current anthropogenic climate change. Remarkably, none of the papers disagreed with the consensus position.
>
> Admittedly, authors evaluating impacts, developing methods, or studying paleoclimatic change might believe that current climate change is natural. However, none of these papers argued that point (Oreskes, 2004).

Another investigation conducted at the end of 2008, which surveyed Earth scientists, showed that vast majority of those surveyed agreed that in the past 200-plus years, mean global temperatures have been rising and that human activity is a significant contributing factor in changing mean global temperatures.

Another study, conducted by academics from the University of Illinois, used an online questionnaire of nine questions and investigated opinion of the scientists listed in the 2007 edition of the American Geological Institute's Directory of Geoscience Departments. The two key questions were: Have mean global temperatures risen compared to pre-1800s levels, and has human activity been a significant factor

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in changing mean global temperatures? About 90 percent of the scientists agreed with the first question and 82 percent with the second (Surveyed scientists agree global warming is real, 2009).

In another study surveying 3146 Earth scientists and with regard to the two primary questions

1. When compared with pre-1800s levels, do you think that mean global temperatures have generally risen, fallen, or remained relatively constant?
2. Do you think human activity is a significant contributing factor in changing mean global temperatures?

Doran and Zimmerman (2009) found that 90 percent of participants answered "risen" to question 1 and 82 percent answered yes to question 2. The researchers also pointed out that as the level of active research and specialization in climate science increased, so did agreement with the two primary questions.

Anderegg, Prall, Harold and Schneider (2010) compiled a database of 1,372 climate researchers. Focusing on scientists who had published at least 20 papers on climate, they produced a list of 908 researchers most active in the field.

They found that most of these scientists accept the evidence for global warming as well as the case that human activities are the principal cause of it. For example,

> of the top 50 climate researchers identified by the study (as ranked by the number of papers they had published), only 2 percent fell into the camp of climate dissenters. Of the top 200 researchers, only 2.5 percent fell into the dissenter camp. That is consistent with past work, including opinion polls, suggesting that 97 to 98 percent of working climate scientists accept the evidence for human-induced climate change (Gillis, 2010).

Misconception 3: There are Discrepancies in the Measurements of Climate Change

The U.S. Climate Change Science Program (CCSP) recently published the report *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences* which addresses some of the long-standing difficulties in understanding changes in atmospheric temperatures and the basic causes of these changes. According to the report:

- There is no discrepancy in the rate of global average temperature increase for the surface compared with higher levels in the atmosphere. This discrepancy had previously been used to challenge the validity of climate models used to detect and attribute the causes of observed climate change.
- Errors identified in the satellite data and other temperature observations have been corrected. These and other analyses have increased confidence in the understanding of observed climate changes and their causes.
- Research to detect climate change and attribute its causes using patterns of observed temperature change shows clear evidence of human influences on the climate system due to changes in greenhouse gases, aerosols and stratospheric ozone.
- An unresolved issue is related to the rates of warming in the tropics. Here, models and theory predict greater warming higher in the atmosphere than on the surface. However, greater warming higher in the atmosphere is not evident in three of the five observational data sets used in the report. Whether this is a result of uncertainties in the observed data, flaws in climate models, or a combination of these is not yet known (Temperature Changes, 2009).

Misconception 4: It is Governments and Business that Need to Act. There is Little an Ordinary Citizen Can Do

Individuals, households, communities, institutions, businesses, organisations and governments must all contribute to reducing greenhouse gas emissions. Is individual behaviour important for combating climate change? Available evidence shows that it is. In the UK, individual behaviour contributes 30 to 40 percent to greenhouse gas emissions (Lawrence, 2008; *Making the Transition to a Secure and Low-carbon Energy System: Synthesis Report,* 2009). The situation is much the same in the US where individuals and households account for about 38 percent of national carbon emissions, a level greater than that of any country with the exception of China. If this is the case, then changes in individual behaviour will not be negligible at all. Much reduction is achievable at low-, no-, or negative-cost. However, when reduction strategies are suggested, they are often proposed as laundry lists, and thus having a small chance of success. The table below, in contrast to usual laundry lists, after considering the advantages and disadvantages of both curtailment and efficiency-increasing actions, prioritises actions in a few simple categories and provides "a short, prioritised, accurate, accessible, and actionable list" of the most effective actions that individuals and households can take to combat climate change:

Table 1. The Short List: Percentage of current total U.S. individual/household energy consumption potentially saved, by action effectiveness.

Action	Energy saved (percent)
For all individuals and households *Immediate low-cost / no-cost actions*	
Transportation	
1. Carpool to work with one other person	Up to 4.2
2. Get frequent tune-ups, including air filter changes	3.9
3. Alter driving (avoid sudden acceleration and stops)	Up to 3.2
4. Combine errand trips to one-half current mileage	Up to 2.7
5. Cut highway speed from 70 to 60 mph	Up to 2.4
6. Maintain correct tire pressure	1.2
Potential savings subtotal	Up to 17.6
Inside the home	
1. Lighting: Replace 85 percent of all incandescent bulbs with compact fluorescent bulbs	4.0
2. Space conditioning: Heat: Turn down thermostat from 72° F to 68° F during the day and to 65° F at night A/C: Turn up thermostat from 73° F to 78° F	3.4
3. Clothes washing: Use only warm (or cold) wash, cold rinse setting	1.2
Potential savings subtotal	8.6
Potential savings subtotal for nine actions listed	Up to 26.2
For all individuals and households *Longer-term, higher-cost actions*	
Transportation	
1. Buy low-rolling resistance tires	1.5
2. Buy a more fuel-efficient automobile (30.7 vs. 20 mpg EPA average-adjusted composite)	13.5
Potential saving subtotal for two actions listed	15.0
For homeowners: Inside the home *Immediate low-cost action*	
1. Space conditioning: Caulk/weather-strip home	Up to 2.5
Immediate higher-cost action	
1. Space conditioning: Install/upgrade attic insulation and ventilation[1]	Up to 7.0

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Action	Energy saved (percent)
Potential savings subtotal for two actions listed	Up to 9.5
Longer-term, higher-cost actions	
1. Space conditioning: Install a more efficient heating unit (92 percent efficiency)	2.9
2. Space conditioning: Install a more efficient A/C unit (SEER 13 or EER 12 units)	2.2
3. Refrigeration/freezing: Install a more efficient unit (replace a 19-21.4 cubic foot top-freezer unit bought between 1993 and 2000 with a new Energy Star unit)	1.9
4. Water heating: Install a more efficient water heater (EFS .7 unit)	1.5
Potential savings subtotal for four actions listed	8.5
Total potential savings for all six homeowner actions listed[2]	Up to 18.0

[1]Roughly 80 percent of older homes are underinsulated, according to the U.S. Department of Energy, "Save Hundreds on Energy Costs", *Consumer Reports,* October 2007, 27.

[2]Approximately 67 percent U.S. households owned their homes in 2005.

NOTES: The potential savings listed in this table apply only to individuals and households that have not already taken the action. Adding up savings across actions can overestimate aggregate savings because of interactions between some actions. For example, the energy saved by caulking/weather-stripping a home will be less if a more fuel-efficient furnace is also installed. The estimates in the "Increased Efficiency" column assume that consumers replace old equipment when it wears out rather than discarding functioning equipment. If consumers replace equipment before the end of its useful life, part of the energy they save by using the more efficient equipment is cancelled out by the energy used to manufacture the new equipment.

Please see Environment's Web site, www.environmentmagazine.org Notes for Table 3, for data entry sources.

Source: G. T. Gardner and P. C. Stern (2008) The Short List: The Most Effective Actions U.S. Households Can Take to Curb Climate Change, Environment: Science and Policy for Sustainable Development, September / October 2008 (updated December 15, 2009).

The first nine actions involve little or no initial monetary cost with six involving curtailment and three efficiency increases (getting frequent tune-ups, maintaining correct tire pressure, and using CFL bulbs). Those who can take all nine actions "can potentially save up to about one-quarter of their total direct energy consumption and a roughly comparable proportion of carbon emissions…The eight higher cost, efficiency-increasing actions together can potentially save up to about one-third of total individual / household energy consumption and carbon emissions. Individuals or households who can take all 17 listed actions can potentially cut their consumption and emissions by half" (Gardner and Stern, 2009).

Misconception 5: We Can't *Afford* to Address Climate Change

Table 1 below summarizes the likely impacts of climate change by an incremental increase in mean average global temperature. It should be emphasized that all predictions of emissions scenarios and likely temperature changes are estimates, not exact figures (Ackerman and Stanton, 2006):

Table 2. Likely Impacts of Climate Change.

Temperature rise by 2100	Likelihood	Effects
0.6°	*Has already occurred*	• More frequent extreme weather events, more floods and more droughts, more heat waves; • A slow pole-ward migration of plant and animal species, with less mobile and less adaptable species increasingly at risk of extinction.

Temperature rise by 2100	Likelihood	Effects
2°	*Will be exceeded unless there are immediate and vigorous efforts to reduce emissions*	• More tropical diseases over a wider geographical area; • Decreased crop yields in the developing world and, as a result, widespread hunger; • Many communities facing serious water stress and widespread droughts; • A total loss of arctic ice and the extinction of many arctic species; • A near total loss of coral reefs due to "bleaching;" • And perhaps the onset of the complete melting of the Greenland ice sheet, slowly but unstoppably raising sea levels by 7 m over the course of the next 3000 years.
3°	*Extremely likely without major efforts at reducing emissions*	• Decreasing crop yields in the developed world and decreasing world food supplies; • Widespread species extinctions and desertification; • The wholesale collapse of the Amazon ecosystem; • The complete loss of all boreal and alpine ecosystems.
4°	*Likely with no efforts at reducing emissions*	• Entire regions will have no agricultural production whatsoever and the melting of the West Antarctic ice sheet will gradually increase sea levels by 5 to 6 m (in addition to the increase from the loss of the Greenland ice sheet).
>4°		• There is a 50-50 chance that the ocean's circulation system will shut down, removing the crucial currents that warm and stabilize the climate of Northern Europe.

Source: (IPCC 2001b; IPCC 2001a; Watkiss et al. 2005). The climate change scenarios cited here are B1 (2.3° by 2100), B2 (3.0°), and A1F1 (4.8°) from IPCC 2001. Table in: F. Ackerman and E. Stanton, Climate Change – The Costs of Inaction, 2006.

In addition to the likely impacts of climate change as mentioned above, another important point on 'affording' climate change is the financial aspect of it. Stern (2010) has presented the state of affairs on this issue well:

Under different policy regimes there may be four possible ways of tackling the costs of action and inaction regarding climate change. These include the role of ethics and discounting, the role of risk and the scale of possible damages.

The first approach focuses on probabilities of the increases in temperature vs. the consequences that would result from such increases. On the basis of the accumulated scientific knowledge so far, most would agree that potential temperature increases, from say 3 to 5 degrees C, would mean that the costs of inaction far exceed the costs of action.

A second related approach on the costs of inaction in relation to the costs of action is in terms of prospects of growth and development and proposes that uncontrolled climate change in a time span of 50 or 100 years will be a serious obstacle to achieving continued economic growth in both the industrialized and developing world.

A third approach involves thinking about the nature of the world and the quality of life which would result from inaction vs. strong action, i.e. a more collaborative, cleaner and safer way of living vs. growing pollution, continuing waste and destruction of forests and biodiversity. Although quantifying such comparisons may be very difficult, nevertheless, anyone can imagine the different consequences that would result from the adoption of different strategies.

The fourth approach is about quantifying key impacts from climate change via formal modeling which involves attempting explicit estimations of the costs of damages avoided by a given strategy relative to another. Although these efforts can be best described as "simplified macro-level models that

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force many complex phenomena into just a few variables", nevertheless, they all illustrate that "the risks involved in a 'business as usual' approach to climate change are very large."

Extended Activities

After the end of the in-class discussion it is important that students engage in activities which will strengthen the gains of the in-class activity just completed. There is, therefore, a need for questions and activities to link previous and new knowledge and to make good use of the existing experience so that the learner can move ahead, to new horizons. The goal of education is not only to extend a person's knowledge but also to help him acquire skills of life-long learning (Theofilidis, 1988).

- Using brainstorming, the teacher asks the students to state anything they know about a climate change issue, e.g. climate change and human health, climate change and protected areas or economic costs of climate change. Everything they say, e.g. beliefs, definitions, causes, consequences, solutions, is recorded on the board. During the time student ideas are recorded, no attempt is made to classify or evaluate this information. Any attempt regarding classification or evaluation is done by the teacher or by both teacher and students after completion of the brainstorming session (Frederick, 2000).
- The teacher asks the students to work in pairs with the aim of creating a lesson plan that addresses a misconception about an issue related to climate change which they believe constitutes a barrier for learning. In the interests of creating a multiple set of lesson plans, which interested individuals can use to address multiple misconceptions surrounding climate change, only one pair in the class will be allowed to develop a lesson plan for a given misconception (Rudge, 2004).
- After students are broken into small groups (3-4 students per group), they are given a handout, which contains a question about an issue related to climate change and six possible responses – each displaying at least one misconception about the particular issue. The six options that students are asked to evaluate are actually slightly edited student responses to the same question taken from old exams. The groups are asked to select the answer that they think is most correct and to identify specific problems with each of the other answers. The groups are then polled to see which answer they felt was best. Finally, different groups share the problems they identified with other answers (Udovic, 2009).

Conclusions

There can be little doubt that climate change will be a significant issue, and possibly one of the central challenges to humankind, during the life time of today's students. Students of today will be the adults and leaders of tomorrow. They will face the future impacts of climate change and need to adapt to a changing environment. One of the most serious impediments to engagement with climate change issues is not what we do not know as much as the things we *do* know that just are not so. Simply providing students with the right information may not be enough. In order to help students correct their misconceptions, teachers in institutions of higher education need to use active, rather than passive, learning approaches. Following a brief literature review on cooperative learning, this paper defined the term misconception, listed the possible sources of misconceptions, discussed five misconceptions students often have about climate change and put forward some cooperative learning techniques teachers can use to address the problem, at the same time bearing in mind its complexity. Some benefits of such methods are:

i. Involvement

People feel involved as part of the educational process, which moves away from traditional messages such as 'I say, you listen' to a dialogue in which 'let's talk', as a method and as a teaching style, is used.

ii. Partnerships

Instead of 'I will do it', approaches in line with the principle of cooperation, such as 'we shall attempt to do it' may be used and in many cases prove to be more successful.

iii. Interdisciplinarity

As climate change is not a matter fully within the domain of any given subject, its understanding requires knowledge of and awareness about the interconnections between subjects and their interrelationships.

Due to its importance and the fact that climate change is a matter of great relevance to future decision makers, it is important that it is duly addressed as part of university programmes. In addition, it needs to be properly dealt with and addressed in an interdisciplinary way. Addressing misconceptions is certainly a set forward in that direction.

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Appendix

Name ___________________________________
Date ___________________________________

Climate Change Misconceptions True-False Quiz

A misconception is a mistaken idea or view resulting from a misunderstanding of something. There are many misconceptions regarding climate change. Read the five statements below. Each relates information about climate change. After each statement, circle the T if you feel that the statement is in fact true and circle the F is you feel the statement is false.

The climate is changing due to natural variability rather than human activity	T	F
Climate change is a deeply contested issue among scientists	T	F
There are discrepancies in the measurements of climate change	T	F
It is governments and business that need to act. There is little an ordinary citizen can do	T	F
We cannot afford to address climate change	T	F

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Evangelos Manolas	PhD, Assistant Professor, Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace, 193 Pantazidou Street, 68200 Orestiada, Greece. Phone: +30 2552 0 4157, Fax: +30 2552 0 41192. E-mail: emanolas@fmenr.duth.gr Website: http://www.duth.edu/
Walter Leal Filho	PhD, Senior Professor, Research and Transfer Centre "Applications of Life Sciences", Hamburg University of Applied Sciences, Faculty of Life Sciences, Lohbruegger Kirchstrasse 65, Sector S4 / Room 0.38, 21033 Hamburg, Germany. E-mail: walter.leal@haw-hamburg.de Website: http://www.haw-hamburg.de/international.html