Forms or models of higher education in facing the effects of climate change

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Distinguished speakers, esteemed guests, dear organizers, ladies and gentlemen. I am delighted that I have the opportunity give this key note speech at this conference, here at the Philippine Caribou Center, in the Science City of Munoz. I was already invited for the 2004 September conference, but I could not make it because of a sabbatical leave in Cedefop in Thessaloniki, in Greece, which is the European agency for the development of vocational training. And it took over three years to finally get here and share with you some thoughts about the issues of this conference in general, and the relationship between climate change and education in particular. When I was preparing my contribution, I was asking co-workers of my Department what they thought would be the effects of climate change on education, and they said that schools would have to install more air conditioners.

More seriously speaking, in October I was having dinner in a hotel in Kampala, Uganda, where I was for a project on curriculum development for floriculture. I asked the waiter about the weather of the next day. He said: 'It will be about the same, very wet'. I said: 'Has it been raining much?' And he said: 'Yes, much more that usual, we had floods. That is very strange for this time of the year. It is raining much more and heavier. We even had hail. Normally we would start seeding for the next crops. But that is impossible.' Is said: 'What will be the consequences?' And he went: 'We expect to have hunger and food prices will rise.' And I asked: 'Is there anything education can do?' Then he started to laugh, and said: 'Aahh, nothing, maybe the government will give money to the people to go to the shops.' I said: 'What about teaching students to build dykes (of course a typical Dutch remark), and to build protected areas against flooding.' He stared at me in disbelief and replied: 'No, that is very difficult!' The Netherlands had a catastrophic flood in 1953 in the south-east of the country. Thousands of people drowned. Not long ago New Orleans was hit by Katrina. Many more people were drowned. The Netherlands built its multi-billion Euro Delta Plan to protect areas below sea level against the devastating effects of extremely high tide and very strong storms. Now the Dutch are being hired to design a protection system against the flooding of the region of New Orleans.
What is the point of this story? Not to tell you how great the Dutch are in designing and constructing large water protection infrastructures, but to use the stunning reaction of the waiter who said: 'It is difficult', meaning that he thought it would be too difficult. 'But it is difficult', should be like music in the ears of education, and spark energy to develop that competence in society which is needed to combat the big problems society is facing. In that sense, climate change should be a big challenge for education to address, since it is one of the bigger challenges of society.

Introduction

Climate change is a big issue at the moment. Much research is pointing at the direction that this change is significant. However, there are signs that the public is responding to this issue in a positive way. The most appealing sign of this is the positive reception of the Al Gore documentary 'An Inconvenient Truth', and the public awareness it created about the urgency about the problems it creates. Many scientists have pointed at the fact that climate change is happening steadily, and that it will have a tremendous of not disastrous effect on human life.

There is a debate about the question to what degree climate change is caused by human intervention, or that it is a natural process. However, it is widely accepted that pollution caused by man is the most important factor.

Education has an important role to play in informing young generations about climate change and the changes it will bring about. It also has to generate leaders, managers, designers, technicians, politicians and administrators who will be able to cope with the threats and can contribute to solutions to prevent the worst-case scenario come true.

However, knowledge is not enough to solve the current environmental issues. Values, will to change and the perseverance to achieve sustainable solutions are equally important. Education also has a responsibility in this respect, it should be more than a deliverer of academic knowledge, it is imperative that it supports holistic competence development of students. Interactive modes of knowledge construction are crucial here.

At institutional level, education also has a role to play in realizing a sustainable world. It has to set the right example in terms of environmentally friendly policies and strategies, such as producing its own green energy. But is should also create new programs for jobs that will be created to fight the effects of climate change, and offer research, development and consultancy services to regions that will face structural socio-economic change, such as closing trades and employment losses. In this contribution, the various forms or models of higher education in facing the effects of climate change will be addresses. The title of the contribution sounds a bit reactive. However, education should also be pro-active in this respect. Education plays an innovative role apart from preparing young generations for an existing world. It should cherish creativity, independence, self-management and entrepreneurship; it should be aimed at arranging learning situations that are aimed at solving problems, creating new sustainable solutions for the relevant problems, shaping new futures and challenging practices that are regarded as unfavorable.

Technological solutions are not the sole solutions

Lots of efforts are being put in finding various technological solutions to the climate change. Pacala & Socolow have presented fifteen stabilization strategies in four categories: 1. efficiency, savings and reduction, 2. catching and storing of carbon dioxide, 3. having fuel with only a limited amount of carbon dioxide, and 4. green energy and bio-storage. The strategies are to improve fuel consumption (in terms of performance and efficiency) of cars. This is a technical solution which will take higher production costs, which will inevitably lead to a higher cost price, and thus consumer price. This strategy will therefore only work if there will be some facilitation. The second strategy is reducing the number of miles cars drive. This will necessitate behavior change when it comes to private use; and more intelligent logistics and alternatives for business use. So public and private factors come into play to make these strategies work well. The same holds for the third strategy, which is to improve the energy use of lighting, heating, cooking and kitchen amenities. This will also be more expensive in the beginning, and the question is whether the consumer will pay for that. They also need to see the returns on investment, because,

if they don't, they will not purchase more expensive machinery just for sustainability reasons, which is very visible in the organic food market. Although the public opinion is to cherish organic production, and there is massive dissent with the industrial agricultural production methods (such as in animal production systems), the vast majority of the consumers are not willing to pay the price which goes with these products. The percentage of the organic market of the whole food market is still in single digits. The problem is that consumers are not emotionally attached to the animals which were processed and of which the products are sold in supermarkets. Of course one can say they just don't want to know, but even if they know, purchasing behavior is not essentially influenced by this, at least for a large part of the consumer population. The same goes for the fourth strategy, which is to improve the efficiency of coal or gas heated power plants. Only with for instance subsidized price reduction consumers are willing to switch to green energy. This at least is the lesson of consumers in the Netherlands, who have been able to opt for green power. As long as this is cheaper, it sells.

Other predominantly technical strategies are to provide coal or gas heating energy plants with sub-terrain storage for carbon dioxide, to use the catching of coal heated hydrogen plants for fuel production for cars, or for coal heated synthetic fuel productions plants. Of course there are the strategies which are propagated since a long time of replacing coal heated power plants by gas heated power plants, or by nuclear energy plants. The latter strategy has gained a lot of criticism in many countries around the world, of course because of the active waste and disasters (like in Tsjernobyl).

There are also the strategies to gain more energy from wind mills and solar energy production systems. Wind energy can also be used for producing hydrogen for fueling battery cell cars. Then the production of ethanol is talked about a lot, and various chains have been developed to produce, distribute and sell this, requiring the cooperation of oil companies to set up a distribution network. In some countries this is working well, in others, there is hardly any ethanol for cars available at all. There is also the big discussion about the side effects of this strategy, which is that it takes about 16% of the total arable land world wide to grow crops to meet the needs of the fuel market. Needless to say that this land will also be found in cheap labor or poor countries, in which there will be even stronger competition about the land and its crops. In stead of feeding the poor, the crops are being exported for energy consumption abroad.

Then there is the strategy of bringing an end to deforestation. However, the contrary is still happening, also because of the large wood consumption need in China, which is developing very fast, and which currently increases the wood prices considerably.

Lastly, there is the strategy of using soil in a sustainable way. However, much research has shown that this is hampered by social-economic factors such as ownership, culture, margins, and different stakeholders having different interests.

As said, these are predominantly technical solutions to the challenge of climate change, and if they are followed up properly, they will indeed reduce carbon dioxide emission considerably. Socolow and Pacala even calculated the value of implementing the strategies they have suggested, and related this to future scenarios of price development. These range between +2°C to +5°C during the years until 2057. They estimate that most of the measures need to be implemented simultaneously to reduce the present growth, which on the long run heads to 800 to 450 particles per million (ppm), which would lead to a temperature rise of +2°C. The present growth

rate would end in a temperature rise of about +5°C in the time frame mentioned (the coming fifty years.
Behind many of the proposed measures are enormous commercial interests and various strategies are more expensive than the lesser environmentally friendly ones. Some belief that the life style, or the way of doing business (like transportation) need to be adjusted. The political, but also economic will need to be in place, to realize the measures mentioned, otherwise there will be no behavior change. Although this sounds a bit pessimistic (or realistic?) there are various good examples. The mere fact that the origin of food products is printed on the packaging (especially on dairy, meet and processed meat, but also vegetable and fruits), resulted in a change in one of the big super markets in the Netherlands. As soon as it appeared that a certain species of fish had traveled like 18,000 km before it was ready to sell in the supermarket, the directors of the company decided that this fish would be deleted from the product list, and it was removed from the freezers. So transparency of product origin can make a difference in sensitizing big actors in the food chain to change their practices towards sustainable business.

Levels of effects of climate change and education

Climate change has effects for education at different levels. Figure 1 (which was used in a different context and in a different way to study the sectoral approach in vocational education, Mulder, 2006) shows various system levels at which these consequences and educational policy measures can be positioned. In that project *types of green competence development projects* were studies for which the following categories for intended results were used: ‘1. instructional materials (including teaching guidelines) focused on use in institutions for vocational education; 2. curriculum materials (including new programs) also focused at implementation in educational institutions; 3. needs assessment in the sector (including the development of occupational profiles); 4. implementation of innovations in the sector (including training of workers and unemployed, the use of accreditation systems, and distribution of project results through social partner organizations); 5. employment improvement (including development of occupational sectors and sectoral certification systems).

The perspective from which these categories are developed is the institute for vocational education (the training provider). Theoretically, the categories are based on work of Romiszowski (1981, 1986) on instructional systems and wider systems. A comparable way of thinking from systems theory in the field of higher education and sustainability is employed by Sterling (2004, 52) when he speaks about nesting systems and the ecosphere, society and economy, and education as nested systems. So, Figure 1 depicts the systems levels of the different types of results. The wider the system, the more important the socio-economic environment, the more the inclusion of sector organizations in the project partnership is needed. The idea behind this set of categories was that the context of instruction is the curriculum, the context of the curriculum the educational institution, and the context of the institution the region with its socio-economic infrastructure, and next the whole society. For curriculum and instructional development needs assessment in the sector is needed (when it comes to sector specific competence development), and if the intention is to disseminate and implement the results of the development projects in the sector, sector involvement would facilitate this.

The categories are also based on work of Tanner & Tanner on curriculum development (Tanner & Tanner, 1995), Walker (1990), Mulder (1992) and more recent work of Mulder, Wesselink & Bruijstens (2005), who showed that different stakeholders have different opinions about the curriculum and that they should be included in curriculum deliberation processes.

Figure 1. Systems levels of climate change issues in education

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From the changes in the natural environment, which are understood as widely as possible here, there are various interactions with society, also taken very broadly. The changes of the natural environment (such as changing habitats of insects) are influenced by activities in society (such as excessive carbon emission), and the activities in society are influenced by factors in the natural environment (such as changing hazardous health areas and medical treatments of previously foreign diseases). Changes in the natural environment and society are related to changes in the labor market and employment in the sense that whole sectors are subject to regional production conditions. Certain fertile areas may start to suffer from decreasing precipitation and thus draught, which may change them into poorer areas. Jobs in certain areas, such as in crop production may disappear, and workers have to find a new livelihood. Re-schooling, adult education, and corporate training may help to alleviate this process and to overcome the many negative effects of labor market restructuring. Part of the population in regions in which this takes place may migrate to economically more favorable regions or even countries. The uptake of these migrants in new contexts can to be facilitated by courses which can be taught by educational institutes (but also by community centers and NGOs). In the Netherlands, immigrants need to take integration courses, and institutes for vocational education and a couple of private training organizations are supposed to teach these courses. However, enrolment currently lags far behind the agreements with the government (to the level of 1:10). Nevertheless, integration education may help to prevent social exclusion (such as happened in China with the rural population which was forced to migrate to urban areas, and now back). Of course, participation on the labor market is essential here, because of which UNEVOC estimated that millions of jobs need to be created, which needs public support given the labor market imperfections.
Educational institutions are facing the effects of climate change, but their responses are different, depending on the way they perceive the urgency of the matter. Some of them are real innovators, and proactively implement policy that specifically addresses the issues related to climate change. They can adopt strategies which are aimed at preventing pollution and adding to their sustainable delivery of services. On the other hand, they can also choose to set up new programs specifically aimed at jobs and roles in fields like environmental technology or multi-stakeholder process facilitation. If universities and colleges have included sustainability in their charters or mission statements, they can support the integration of this field in the courses they are teaching, or by introducing new courses or specializations (such as majors or minors) or even new programs (such as complete Bsc and MSc programs). Within education which is aimed as sustainability targets, an important question is how to facilitate the acquisition of sustainability competence.

Effects of climate change on education and educational responses

The various effects of climate change on education and educational responses will be presented in this section. The effects educational responses will be categorized by the levels of effects as indicated in Figure 1, and as specified Table 1. The list of effects and educational responses are examples, and by no means meant as exhaustive. Reality in different countries in the Asia-Pacific, but also in Europe and the Americas.

Table 1 Levels of effects of climate change related to education, effects of climate change related to education, and educational responses to the effects

Levels of effects	**Effects**	**Educational responses**
1. Society	1. Public policy making	• Awareness, inform decision making
	2. Enforcement	• Informing
	3. Raising public awareness	• Informing, sensitizing
	4. Raising worker awareness	• Corporate training, education, development
	5. Sector education policy	• Sector programs and projects
2. Employment/labor market	6. Migration	• Acculturation, inclusion, participation
	7. Labor market restructuring	• Re-training of workers
	8. Climate change as field of work	• Education programs
3. Educational institution	9. Widening external relations	• Knowledge co-construction
	10. Setting an example	• EE policy making • Implementing EE practices
	11. Beta-gamma interaction	• Inclusion of integrated beta-gamma education
4. Curriculum level	12. Sustainability competence needs	• Identification of future competence needs
	13. Sustainability competence development approaches	• Competence-based curriculum • Competence assessment • PDP and portfolio
5. Teaching/learning	14. Behavioral change needs	• Integral learning
	15. Needs for inspiring learning arrangements	• Inspiring students

Societal level

At the societal level I am distinguishing public policy making, environmental law enforcement, raising public awareness, raising worker awareness and the sector education policy.

1. Public policy making

At societal level the first effect is that public policy making, or public administration is paying systematic attention to this dossier. The public expects that, and policy experts are sufficiently informed about the necessity of this, and much is already going on. There are various platforms at different levels which deal with the issue of sustainability, such as separated waste management at municipal level, integrated waste management at regional level, setting policy targets at national level, and getting international agreements and treaties and starting and implementing programs (like the Kyoto protocol, and the UN Decade of Sustainable Development). There are also various projects on international cooperation, and private initiatives, such as the Clinton Global Initiative, and other voluntary actions, all aimed at gaining collective commitment. These developments go together with resistance and even conflict, because much is at stake. Different parties in the process have different interests. For this, education has started specific teaching programs for multiple-stakeholder facilitation processes. These programs prepare professionals for stimulating and facilitating interaction processes between different public and private organizations, institutions, groups or individuals, who have vested interests in certain practices. Informing parties, gaining mutual understanding and respect, reaching the most reasonable trade-off, and conflict resolution are key achievements of these facilitators.

2. Enforcement

The second effect at the societal level is enforcement, basically as one result of public policy making. Here I would like to acknowledge the work of Van Woerkum of the Communications Department of Wageningen University and others in the field of public policy making. They have contended that this policy making should follow principles of interactivity. Interactive policy making created a much larger platform, including commitment and compliance, than traditional top down strategies of public administration.
Is serious fields like aviation, the nuclear industry, criminality, financial services, health care, but also in food safety, many countries have agreed upon national and international regulations and enforcement strategies, because incompetent behavior in these areas are detrimental for the population.
For instance, in the food industry the inspectorate and obligatory participation in quality surveys, and international control by for instance the IFPRI can be mentioned. In the field of environmental technology environmental policy and mandatory administration are examples of this.
The typical educational response is that in various respective educational programs new regulations and law enforcement systems are taken up in courses on food law, environmental law, etcetera. In this way new entrants on the labor market are

informed about this. But when large changes occur, existing professional also need to be informed, which can be done by large campaigns, which for instance happened with the introduction of the new VAT law in Australia some years ago.

3. Raising public awareness

The third effect of climate change at societal level is the raising public awareness of the problematics that are related to that. All around the globe people are talking about the changes in the weather. In Africa, close to the equator, I was sitting on a terrace when it was feeling fresh and I had to put on my blazer. Young colleagues were wearing sweaters while freezing. They spoke about the weather as being wintery, which was quite unusual. It was much too cold too long for that time of the year. I think the documentary of Al Gore, an Inconvenient Truth, which I mentioned before, has to be mentioned here again, since it has been very influential on the attitude of the population in general. There is progress in this respect, which leads to behavior change, but the schizophrenia of the citizen and consumer can be reiterated again, and it also has to be said that some life styles, such as skiing in Dubai, do not really add to sustainability. Recycling and reduction strategies have to come first, since they add to the achievement of sustainability targets.
For education, there is a specific role to play in this respect. Educational institutions can start cooperation with public and private agencies for sustainable development, such as NGOs, municipal departments, centers for environmental education, as well as regional and national projects and organizations. The educational infrastructure can also be used to interact with the local population in courses and workshops in which climate change is addressed, to sensitize them for this field if they are unaware of what is happening. Using the – often – elaborate networks of schools, colleges and universities as well as the teacher training centers is now the core of certain strategies to communicate information which is essential for society.
To influence public awareness, the sector itself can also implement specific projects like ‘adopt a chicken’, or pig farm observation windows at farms.

4. Raising awareness of workers

Apart from raining awareness of the public, workers should also be addressed. The typical effect of climate change at corporate level is that they set up a program for corporate social responsibility (CSR). They can do that at different levels, ranging from mere minimum compliance with the regulations to an internally felt commitment to a better world. Some companies support wild life protection programs, or other nature conservation projects. A cautionary remark can be made here, because organizations can employ these strategies for marketing reasons, so the details of these initiatives have to be studies first to judge whether they are really adding to the environment. Many of them are.
When companies have set CSR targets of companies, a corporate CSR strategy is developed frequently. After that, corporate regulations, cultures and practices (e.g. in the construction or catering sectors) need to be reviewed and adjusted where necessary.
Employees can be confronted with the consequences of the corporate sustainability policy by means of training, development, coaching or consultancy activities. To take

real effect, these activities have to be embedded in structured strategies and practices of human resource management. Geiser (2006) gives examples of this kind of training and development, for instance in the field of reducing use of toxics by professionals.

5. Sectoral education policy

The last effect of climate change at the societal level is sectoral policy development. Whole sectors are making plans on how to deal with aspects of climate change. The agricultural sector builds scenarios, at the national, but also at the international levels. In a study of Luttik et al (2006) (from Mulder, in press), it is stated that '… agriculture may disappear in Western-European countries like the Netherlands. Four development pathways are distinguished as futures of land-based agriculture: eroding agriculture, changing agriculture, innovative agriculture and from land-based to sea-based agriculture. Based on these scenarios, nine draft ideas are developed based on which land-based agriculture can develop itself: 1. sea-based agriculture (agriculture in the sea, which is sea-based industrial production of various wet-land based healthy nutritients: fish, shell-fish, alga, crops), 2. bioport (turning the economy from fossile to biomass energy production, contributing to sustainable energy consumption), 3. demand driven micro-chains (in stead of supply-driven bulk-chains), 4. local autonomy (in stead of central provisions), 5. boundary crossing food (eating as a way of bringing people of different cultures together), 6. nature at your fingertips (making nature more attractive by partially virtualizing it), 7. dying with dignity (about a new experience in the terminal phase; think of hospices in beautiful natural environments with high quality care), 8. value driven financial arrangements (demand-driven planning of the landscape in stead of subsidy systems), convenant society (away from the government-regulated market economy to a self-managing network society).'
Also at the level of the European Union scenarios for the future development of agriculture and rural development have been created, basically disappearance, stabilization and growth. It will be clear that if a certain scenario will come true, this will have many consequences for the inclusion of certain education programs in the course syllabus.
Within the agricultural sector in the Netherlands, there are many sectoral initiatives, such as the reduction of carbon dioxide emission from greenhouses, and turning greenhouses into sources of energy in stead of massive users of energy. Association governors are being educated in the new issues, as well as management of sectoral organizations and experts in sectoral organizations, because many of them have to lead and facilitate sustainable sectoral development, like greenhouse production. Also, from an economy of scale perspective, educational institutions in the agricultural sector make agreements on the places at which institutions certain special programs are being taught. Maybe a special program on climate change or sustainable development draws too few students to be taught at all places of the universities, and regional agreements are being made about who teaches which programs. Needless to say that this sometimes is a difficult process.

Employment/labor market level

At the employment and labor market level, three effects are being presented here: migration, labor market restructuring, and climate change as a field of work.

6. Migration

Migration is seen as an effect of climate change because significant changes may cause whole populations to move. This may take place in regions that are hit by extreme temperature rise, draught, or on the contrary, abnormal precipitation and flooding. Changing living conditions for migrants necessitates cultural integration, acceptation, and basic education in the language and culture of the new society. There also is a necessity of learning to work in the new context.

7. Labor market restructuring

For the people who stay behind in regions which are hit by extreme climate conditions, a restructuring of the labor market or employment, including self-employment has to take place. The type of economic activity will change. Complete sectors may disappear, and a new line of business needs to be generated. This calls for important coping strategies of workers, searching for new employability. But job creation also comes in place, which is not easy without public support. For these labor market reconstruction areas, the EU has the so-called restructuring funds, which were heavily used in regions with high numbers of unemployed and immigrant people, such as the previous coal mine sector, metal sector, textile sector and also agricultural sector, which is now converting in a rural sector for multifunctional use like country-side living, tourism, care and nature conservation (see Hortet in press). Education can pick up many of the re-training needs and make customized training programs for persons who want skills in new areas that are profitable in the region.

8. Climate change a field of work

Climate change itself is a growth market in terms of the organizations working on it, or companies that produce new technology for reducing the negative effects of it. So climate change is a growing field of work. More education is needed for that, which means that there will be higher pressure on the pertaining programs. Examples of labor market segments which will show a growth of employment opportunities are the climate control industry, the CO_2 emission reduction technology sector, the environmental technology measurement device sector, the clean air industry, the clean water industry, and of course the food quality sector.
There is also job growth in non-technical sectors, like the financial sector, because of climate change. The CO_2 emission sector has introduced the trade of emission rights, which is being done at the carbon dioxide emission exchange. This created a completely new trade sector, with new jobs attached to that, and a specialized education program for that.
Education typically responds on four levels when it comes to introducing a new field of study: 1. new elements in existing subjects; 2. the introduction of new subjects in existing programs; 3. the introduction of new differentiations and specializations in existing programs; and 4. the introduction of new programs.

Educational institution level

At the level of the educational institution three effects are being discerned: the interaction with external relations in the field of climate change, the setting of a good example, and the introduction of new programs as mentioned above.

9. External relations

Schools and colleges which want to take serious action when it comes to climate change often engage in external relations to build up a networks in which knowledge about innovative practices can be exchanged. In the Netherlands again, a program on knowledge circulation is being implemented to stimulate educational institutions in making contacts with research organizations and enterprises. This institutional cooperation takes place by having student groups doing research projects for companies. These student groups are being guided by researchers and do their project for specific organizations, like farms or food production factories. This process is also referred to as cooperative knowledge construction, as all parties involved learn from these educational research projects.

To elaborate a bit on this, two projects were implemented in the Netherlands, one on knowledge co-creation and one on knowledge arrangements. Both will be summarized here.

As to the project on knowledge circulation (Potters, Van der Hoeven & Gielen, 2006; Lans, Kupper, Wals, De Beuze & Geerling-Eiff, 2006) in this project it is emphasized that effective arrangements between research institutes, industry, and educational institutions should be created, to inform education about the developments so that they can be integrated in their programs and to implement new interactive and participative initiatives in which students can develop competencies and expertise the need.
In the project called 'Learning with future' (Potters et al, op cit), three pilots of innovative arrangements between education and research were tested in cooperation with the Clusius College Hoorn, CAH Dronten and INholland Delft.
First of all causes and consequences of suboptimal cooperation between research and education were analyzed and a model for future oriented learning was developed. The key causes of limited cooperation between education and research institutes were related to lacking overlap between the networks, little vision on cooperation and low priority, and restricted concepts for cooperation. All this resulted in limited vitality and sustainability in agriculture. Practical networks were not used as learning environment, new knowledge does not flow into educational innovation, chances for preparing students for professional practice were under-used, capacity for research of education was not used, which leads to less innovation power.
After these observations, two meetings were organized in which perspectives were shared and opportunities for cooperation were identified. The concept of learning with future revolves around the idea that structural cooperation only starts and continues as long as the various stakeholders have mutual benefits of it. Because of this participative methods were used to develop cooperation, and the project team played a facilitating role.
Based on the meetings three draft proposals were developed and the proposal which had the strongest support was elaborated and tested by three pilot core teams. The project gave room for exchanging experiences and go beyond traditional boundaries

between entrepreneurs, research and education. The partners in the projects thus learned about new opportunities for cooperation and developed ideas for institutional integration of the ideas.
The core of the pilot projects consisted of student teams who were working on questions of entrepreneurs who participating in a practice network of a research institute. During the projects students could develop the following future oriented competencies: 1. strategic entrepreneurship in networks; 2. translating research findings into practice; 3. working in a teams and project management; 4. communication: deliberation, making agreements, informing, interviewing, human relations, report writing and presenting.
The student teams worked independently, but they were supported by researchers, teachers and consultants. Teachers were coaching the learning processes and created a safe learning environment, researchers and consultants gave advice regarding the content of the projects and the research process. The entrepreneurs served as project commissioners, but also acted as practical experts and information sources about the company.
As said, three pilot projects were implemented, one on biological agriculture, one on open integrated cultivation, and one on greenhouse horticulture. Reactions of all stakeholders about this interactive entrepreneurship-research-education model were very positive. Participants said: ‘This is REAL education’, ‘This is much better than doing an internship in a company. One makes the link between theory and practice. In other internships one in fact just works along in practice. Now one wants to also see what an entrepreneurs has on paper inside’, and ‘One learns things one normally does not learn in the program, for instance how one can get as much out of an interview as possible’.
Lessons learned were about the cooperation and knowledge circulation between the actors, and structural embedding of the model.
Regarding the cooperation and knowledge circulation it was found that the choice of the theme for projects influences the perceived value of the project for the partners. It is important to choose a specific question of entrepreneurs, to relate to project theme to current research which fits it the running research program, and to link it to existing educational programs and themes of educational innovation. Furthermore, the right persons who have the right competencies should be linked together. Also, the learning project should be well defined, and a start-up meeting is essential. Clear communication, quality management and the flow of knowledge are also important. As for the institutional embedding vision development, agreements, flexibility in added value, a joint year calendar, organizational support from all actors, keep watching overregulation, financing, training and coaching of teachers, researchers and entrepreneurs, linkages with innovation processes, and appointing a coordinator within the participating organizations are important.

The second project mentioned (Lans et al, op cit) was about knowledge arrangements as powerful learning oriented combinations of groups of actors. Ten of these knowledge arrangements were monitored, about cow and chances, poultry knowledge, declaration-obligatory animal diseases, duration cultivation, crop protection, new style tree nursery, learning with future (described above), pre-university campus (a service of the university for students of pre-university education for instance for the support of students who have to make assignments in field that are covered by the university), knowledge circle food safety (a knowledge circle is a group of experts around the relatively new position of reader in higher professional education, who has the task of

innovating educational programs, creating new programs, and to do practice oriented research), and the rural house of a specific region in the Netherlands. All knowledge arrangements were analyzed, and again lessons were distilled that are important for setting up and maintaining good and innovative practices. Competencies were identified which are essential for these arrangements, and guidelines were given for 'directors' of them, based on 1. the four factors identified in this study that are important for success: vision, support, competence and culture, and 2. the three levels of the actors: individuals, organizations and the networks. Directors can assess the situation of a knowledge arrangement on theses factors and levels and decide on a deliberate strategy to orchestrate (and develop and manage) the arrangements.

10. Giving a good example

An effect of climate change is also that educational institutions want to give a good example in sustainable behavior. They do not stick with a code of conduct, but actually realize things like carbon neutral enterprise. Wageningen University does that for instance by maintaining its own green energy supply; it has wind mills which generate sufficient energy for the whole university and research center. Needless to say that setting a good example is much more powerful that preaching the blessings of sustainable behavior without any care for the internal processes.

11. Beta-gamma interaction

As said before, sustainability is a concept at the interface of beta (technical, hard) and social sciences (Röling, 2004). It is not enough to just focus on technological issues when sustainability challenges are at stake. The human factor is as important, since humans have created many problems that cause sustainability challenges, and solutions very often imply negotiated changes in human action. Therefore, at various universities, this interaction between the beta and gamma sciences is advocated, both in research and education. In an evaluation study of beta-gamma interaction in education in the department of environmental sciences at Wageningen University (Mulder,Van Loon & Broekman, 2004) it appeared that this interaction is by no means easy. Different educational cultures (if not paradigms) come together, and if students are being supervised by teachers from both sectors, the chances are high that the teachers have different assessment standards in mind when it comes to the quality of the student work in their fields. Teachers in the beta sciences have higher standards regarding the beta component of the student work, whereas teachers in the social sciences use higher standards regarding the social component of the student work.

Further findings of the study (op cit) were the following.

- Didactics - Problem-based learning and case-based learning are good didactical approaches to realize beta-gamma interaction (BGI).
- Needed BGI knowledge – Important is to determine with which core problems in the subject domain graduates will have to deal and which beta- and social science knowledge is needed for solving those problems. BGI-education needs to be programmed based on these problems.
- Necessity of BGI – Students should get clear examples as to in which way they will be confronted with inter-, multi- or trans-disciplinary work after they

have graduated, and that it is the task of the university to give attention to the integration between core subjects next to further (super) specializations. To make BGI understandable the way in which different disciplines are connected should be clearly indicated: there should be alignment. This can be achieved by presenting a conceptual framework of to make the read thread visible.

- Mutual interest - BGI has to scaffold the stimulation of mutual interest and understanding in one another's content area and the differences in design and problem solving approaches. BGI education should be linked to the zone of proximal development of beta and gamma students.
- Language and way of thinking - Beta and gamma students have to learn to know their mutual language and way of thinking. They also have to be curious to the background of that thinking not only because of getting a better understanding of that, but also to be able to cooperate were necessary.
- Mixed teacher teams – Employing mixed teams with beta and gamma teachers works especially good when good ex ante agreements are made between the teachers involved and there is a clear framework of actions.
- Knowledge of teachers – Both beta and gamma teachers who are being chosen to implement BGI education have to have insight in their mutual domains.
- Continuous learning lines – Multi- or trans-disciplinary problem solving cannot be learned in one subject. That calls for continuous learning lines spread across the program. It is important to program BGI oriented competence development in such learning lines.
- Exams – It is also important to give attention to assessment of BGI competence. Teachers have to be very well aware of different assessment frameworks and accompanying standards. Different disciplines have their own grading practices. Beta teachers may have lower marks in mind when assessing work of BGI groups regarding the social sciences component and vice versa.

Research is going on to study the concept development during the learning process in a beta-gamma program of food safety (Spelt et al, 2007).

Curriculum level

The next level of effects of climate change in education relates to sustainability competence needs and sustainability competence development needs.

12. New competence needs

Another effect of climate change is that it creates new competence needs to which educational institutions have to respond. However, to be able to do so, they need to have a clear picture of the impact of climate change in practice, and assess the new competence needs, and decide if they want to address them, and if yes, how. There are various methods to analyze future competence needs. Ongoing analysis remains necessary for regular updates of the information on which educational programs have been built.

13. Competence development approaches

As said before, educational institutions also can introduce completely new educational programs, such as new Bachelor and Master programs for broad fields (Tanner and Tanner, 1995) to combat the effects of climate change. Various universities have programs for environmental technology for years already, but various new special programs have also been introduced.
Since environmental issues include a knowledge, skills and attitude component, we are conceptualizing education which addresses this as competence oriented. By this we mean that students not only have to develop a large amount of knowledge, they also have to have the skills to apply this knowledge, and to do this with a constructive attitude towards realizing sustainable development.

We will come back to the whole notion of competence development in the last section of this contribution, since we see it as a crucial innovation in higher education, which at the moment gains worldwide attention.

In an orientation on educational responses to diverse expectations of the public, Mulder & Eernstman (2006) have distinguished various educational innovations, or rather educational practices that in HAE institutes (in various European countries) consulted were observed as being important for the challenges and respective competence development issues identified. These educational practices are listed below.

- Organizing language courses at university or making language courses very accessible
- Organizing subjects on intercultural education
- Organizing student-exchanges between different countries
- Inviting foreign students to a university
- Strategic networks with leading international universities
- Interdisciplinary education
- Trial stations, in which students learn the practice of agriculture
- Merging universities with more practical educational institutes
- Organizing lectures together or designing joint Master programs
- Merging more practical and theoretical knowledge
- External students (organizations) provide more practical education for students
- Thematic courses; Academic Master Cluster
- Project oriented education to make students judge by themselves and think of solutions
- Providing a student divers stock of knowledge and opinions that students then merge in order to come to new conclusions; this gives them knowledge on both the details of an issue and an overview; for example, different scientists organize a lecture on plant, one of them will focus on cell-level, the next focuses on the plant as a production system, the third looks at the plants in relation to animals, etc.
- Problem-based learning
- Courses on communication skills
- Organizing opportunities in which students practice presentations
- Multi-stakeholder projects: students are taken away from the scientific world and drawn in practice, as stakeholders come up with practical questions and issues that automatically are more holistic
- Joint lectures: a subject is taught by a consortium of different experts/lecturers; they all focus on a different component of the issue; joint lectures

- Education-industry collaboration
- Venture Cup and Yearly industry convention

See for other curriculum responses to the issue of sustainability the work of Lowry and Flohr (2006).

Teaching/learning level

Finally there are effects of climate change on the processes that take place at the level of teaching and learning. This effect is not direct, but subject to the activities of teachers in educational practice, and ways in which students appreciate, interpret and utilize the learning arrangements that are being created for them. There are two effects we distinguish here: behavior change and the implication of that in teaching and learning, and the design of inspiring learning arrangements.

14. Behavior change needs

Climate change can only be counter-acted by human action. Values, preferences and customs need to change, to support behavior change. This directly relates to the previous educational response of competence development, which, as said, not only refers to knowledge, but also to the ability and will to apply this knowledge. Behavior change is also related to transformative learning, which means learning to look at things differently (Sterling, 2004). Viederman (2006) however contends that learning and behavior change can not easily be fostered by universities, but higher education needs to focus on that, and there are various possibilities to do so.

15. Needs for inspiring learning arrangements

Climate change leads to the need of seductive learning arrangements in which students not only are challenged, but also inspired to do something about the problem situation. There are various ways of implementing inspiring learning arrangement to promote sustainability competence. There are the interactive, participative ways of social learning (Röling, 2004), strategies to learn from and with each other, inquiry learning and experiential learning (Lowry & Flohr, 2006).

In a project on inspiring learning arrangements for entrepreneurs, prototypes of learning arrangement were developed which are now tested and adapted in higher agricultural education. In this project an attempt is made to design various learning arrangements for entrepreneurs which are inspiring for them to engage in (Gielen, Biemans & Mulder, 2006). It is well-known that entrepreneurs are not very interested in participating in formal education and training courses. Their learning preferences are different (Lans, Wesselink, Biemans & Mulder, 2004), and in an innovative context they tend to rely on reflection, observation and imitation (Mulder, Lans, Verstegen, Biemans & Meijer, 2006). Supporting entrepreneurs in their learning effort is challenging, and the idea was that if learning support would be inspiring, entrepreneurs would be benefit more from it. Therefore, various pilot studies were conducted in which inspiring learning arrangements were found, which were labeled

with metaphors. The metaphors are listed below, and the pertaining competencies are indicated behind the metaphors. Various specific didactic varieties are listed below the metaphors.

- Master class - Insight and experiential knowledge
  - Workshops, cases, court game
- Clinic - Skill
  - Demonstrations, audits, benchmarks
- Workshop - New perspective
  - Brainstorms, mind mapping, creative sessions, scenario-development
- Laboratory - Viability of solutions
  - Model development, practice simulation, research, concept development
- Academy - Multidisciplinary knowledge
  - Classes, lectures, seminars, symposia
- General rehearsal - Collective routine
  - Training, conducting, development of cooperation and routines, presentation
- Entrepreneurs café - New networks
  - Lectures, discussion, team quiz, socio drama
- Boxing ring - Improved performance
  - Debate, panel discussion, game, training and coaching, competition
- Kitchen table - Deepening network
  - Dialogue, group conversation, coaching conversation, reflection conversation, consultancy session
- Utopia - Innovation
  - Discussion, negotiation, presentation to the public
- Study club - Mirroring company results
  - Story-telling, company visit, company audit, systems analysis, presentation
- Expedition - Self-knowledge and new values
  - Excursion, blind date, study tour, survival, journey report

These inspiring learning arrangements are being advised to institutes of HAE. The general idea is that taking authentic learning of entrepreneurs as an example, students of HAE will also be motivated to engage in these activities, in which they then acquire the competencies that are being conceived of as very important.

Other educational approaches

After having given this overview of various effect of climate change on education and educational responses to that, it may also be informative to list some other educational approaches which have not been mentioned yet, but which may be interesting to apply in climate change oriented programs, courses or lessons. The educational, pedagogical and instructional approaches frequently used in the Netherlands are:

- Project education, which is employed for instance to a large extent by the college of Larenstein in Velp (now part of Wageningen University), which addresses social learning in self-directed student teams to a large degree;
- Problem-oriented education (a model which started in the Netherlands within the School of Medicine of the University of Maastricht, and which was adopted in a modified way by Wageningen University), which addresses integrated problem analysis, information finding and processing, team learning, and problem solving;
- Multi-disciplinary design and problem solving (a model developed at various technological universities, but also implemented in a specific way in the Academic Master Cluster of Wageningen University), in which communication of students from various disciplines is developed;
- Computer-based collaborative learning (a model of a-synchronous network-based communication about learning content, knowledge construction and development of collective representations, widely used world-wide, but still in its infancy in Wageningen University (see Mahdizadeh, 2007), which is typically used for content areas in which diverse perspectives are existing, and students can have differences of opinion;
- Video-based case study and problem solving techniques (a way of working with new and sometimes emotional situations with which students may not have much experience, such as HIV-Aids or conflicts); this addresses for instance handling emotions, negotiation, and conflict resolution;
- Entrepreneurial learning, in models of small business education or simulations (such as being practiced in an agricultural college in Goes); inspiring learning environments of entrepreneurs can serve as examples for course activities in higher agricultural education (as studied in the greenhouse sector by Lans et al).
- Competence development, based on competence assessment, personal development plans, coaching, feedback and reflection (widely use, not only in education but also in companies in Europe);

Further studies regarding innovative educational approaches for competence development in the Netherlands are the program on knowledge circulation, beta-gamma interaction in education, competence-based higher education, learning with future, learning of entrepreneurs, and inspiring learning arrangements. These studies will be described in short.

Towards competence-based education

The concepts of competence, competence development and competence-based education are mentioned in this contribution already various times. To elaborate a bit on this, the overarching innovation at this moment is competence-based education.

With competence we mean the integrated set of knowledge, skills and attitudes which are conditional for effective performance. Examples of this are the advice on river management, which requires knowledge about currents, tides, forces, social-economic situation in the river area, skills regarding measurement methods, handling equipment, data registration, and attitudes like objectivity, accuracy and creativity, or on

facilitating multi-stakeholder processes, which requires knowledge about the field, group dynamics, interests of stakeholders, skills like the ability to start a dialogue, to stimulate exchange of opinions and arguments, finding common ground, enhancing transparency of disagreements and attitudes like appreciating to work with heterogeneous groups.

The implementation of competence-based education this innovation is further in colleges for professional education at the undergraduate level than in universities at the graduate level, since the colleges are more oriented towards professional practices, whereas the universities are more focused on academic skills and research. Various principles of and experiences with competence-based education are proposed, based on studies of Wesselink, Biemans & Mulder (2007). A matrix was developed with these principles and levels of implementation. This matrix is primarily meant for competence-based agricultural vocational education, including higher professional education. The principles are (these are further elaborated in the appendix to this contribution):

1. The competencies, that are the basis for the study program, are defined.
2. Vocational core problems are the organizing unit for (re)designing the curriculum (learning and assessment).
3. Competence-development of students is assessed frequently (before, during and after the learning process).
4. Learning activities take place in several authentic situations.
5. In learning and assessment processes, knowledge, skills and attitudes are integrated.
6. Self-responsibility and (self)-reflection of students are stimulated.
7. Teachers both in school and practice fulfill their role as coach and expert in balance.
8. A basis is realized for a lifelong learning attitude for students.

First research into the application of competence-based agricultural-vocational education showed different (Biemans et al, 2004; Mulder, Weigel & Collins, 2007) critical remarks, such as the link with authentic learning which is difficult to realize, the costs and complexity of assessment, the opaque nature of the concept itself, the over-reliance on standardizations, the change of teaching and learning style, and the necessity of implementing competence management for teaching staff. All these can overcome if the right conditions are provided and strategies are implemented to avoid the pitfalls.

Various faculties and universities are now in the process of working with the concept of competence in their programs, also based on the Bologna process, the European Qualification Framework, the Dublin-descriptors, and accreditation requirements regarding the societal relevance of educational programs. Wageningen University takes this very seriously, and has implemented a program of identifying competencies in all programs, and now places this in a wider perspective of the preparation of students for the labor market and society, in which the expectations of the public also play their part.

Conclusion and wider perspectives

The conclusion of this contribution is that there are various effects of climate change on education, and there are various responses to this, at various levels. Education for this field is characterized by its normative and mission driven character, which relates to values and standards. To raise awareness for the problem area, understanding, acceptation and appreciation are needed. This will go along with disagreement, irritation, frustration, and conflict, since competing preferences are at stake. Ways of handling these conflicts are ignoring, dialogue, and conflict resolution. There is much case-based information about educational approaches which address this. A common understanding is that interactive and participative multiple stakeholder processes are needed for facilitating the agreement on the best trade-offs in given situations with conflicts of interest. We see competence development in education as essential for the field of sustainable development. The space in this contribution is too short to elaborate this further. The essentials of this approach and its origins are described in Mulder (2007).

In this contribution the responses of education to climate change are described, and we did not go into the methodology to assess the level of sustainability of higher education institutions. Work of this kind has been done by Roorda (2004), who presented the Auditing Instrument for Sustainability in Higher Education. This instrument is based on principle of quality management and comprises five stages of development of sustainability in higher education: activity orientation, process orientation, systems orientation, chain orientation and society orientation. A criteria list goes along with this instrument, which consists of five categories: vision and policy (on sustainability in higher education), expertise in this field, the alignment of educational goals and methodology to the field of sustainability, the content of education, and the assessment of educational achievement. The instrument can be used in audits of institutes of higher education, resulting in a profile of the extent to which the institutions meets the agreed criteria.

We neither went into the many case studies or national reviews that are presented in the field of education for sustainable development, like the one by Scott & Gough (2004), who have given an overview of the developments in this field in the United Kingdom, the one by Calder & Clugston (2004) about the sustainability initiative by the University of South Carolina, or the one by Koester, Eflin & Vann (2006) on Ball State University.

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Appendix: Principles of competence-based professional education

Source: Mulder, M. (2007). *New Competence-Based Initial and Continuing Vocational Education Policy Making in the Global Economy. Problems and Perspectives.* Contribution to the International Forum on Vocational-Technical Education, organized by UNESCO-APNIEVE and Tianjin Municipal Education Commission, Tianjin, China, 11-13 September 2007.

Principle 1 Competence profile

The competencies, that are the basis for the study program, are defined.

Variables to check the implementation of this principle are:

- Putting together a job competence profile
- Using a job competence profile
- Interaction between education and vocational practice

The complete implementation of the principle means that a job competence profile is put together with participation of actors in the sector and occupation, and that this profile is frequently aligned with regional and local actors in practice including and reviewed against the major trends. This job competence profile has been used during the (re)design of the curriculum.

Principle 2 Vocational core problems
Vocational core problems are the organizing unit for (re)designing the curriculum (learning and assessment).

The main variable to assess the level of implementation of this principles is the extent to which the vocational core problems determine the curriculum.

The maximum implementation of this principle is that core vocational problems have been specified and that these are leading for the (re)design of the whole curriculum of a training program.

Principle 3 Competence assessment

Competence-development of students is assessed before, during and after the learning process.

Variables to check the level of implementation of this principle are:

- Accreditation of prior competence development
- The inclusion of formal competence assessment
- Formulating feedback based on competence assessment
- Ensuring flexibility in format and timing of assessment

The maximum implementation of this principle is that assessment takes place before, during and after the learning process. Assessment is used for both summative and

formative assessment. Students determine moment and format of assessment themselves, in consultation with the teaching staff and assessors.

Principle 4 Authentic learning

Learning activities take place in different authentic situations.

Variables to check the level of implementation of this principle are:

- Authenticity
- Diversity
- Relation between learning in school and learning in practice.

The maximum implementation of this principle is that learning activities take place in a diversity of authentic settings to a large extent, and that they are clearly related with the learning activities in practice, at internship places or based on learning and working contracts.

Principle 5 Integration of knowledge, skills at attitudes

In learning and assessment processes, knowledge, skills and attitudes are integrated.

The main variables to check the level of implementation of this principle is the level of integration of knowledge, skills and attitudes in essential study tasks throughout the curriculum.

The maximum level of implementation of this principle is that integration of knowledge, skills and attitudes is the starting point for both the learning and assessment process, and specified in that sense.

Principle 6 Self-responsibility

Self-responsibility and (self)-reflection of students are stimulated.

Variables to check the level of implementation of this principle are:

- To what extent is self responsibility stimulated?
- To what extent is self reflection supported?
- To what extent is reflection on functioning in the vocational setting organized?
- To what extent are the learning needs of students taken as the starting point for their learning process?

The maximum level of implementation of this principle is that students are responsible for their own learning process based on their own learning needs.

Principle 7 Balancing the expert and coaching role

Teachers and trainers both in school and practice fulfill their role as expert and coach in balance.

Variables to check the level of implementation of this principle are:

- The way in which the learning process is supported
- The extent to which the knowledge acquisition process is supported

The maximum level of implementation of this principle is that teachers stimulate students to formulate learning needs and to manage their own learning processes based on careful self reflection.

Principle 8 Lifelong learning

Students have acquired a positive attitude towards lifelong learning.

Variables to check the level of implementation of this principle are:

- To what extent contributes the educational programs to personal and (labor) identity development
- To what extent addresses the program the development of learning competence
- To what extent is attention given to the future career of the student

The maximum level of implementation of this principle is that during learning trajectories the development of learning skills and (labor) identity are integrated, and that reflection on the future career of the students has taken place.