A Personal Approach to Teaching about Climate Change

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A B S T R A C T

The problem of climate change is complex, global, and long-term, and therefore difficult to grapple with for politicians, scientists, teachers, and students alike. Teachers in particular face the problem of presenting climate change in a way that is not abstract and distant. To engage the intellect as well as emotions, students need to feel personally involved. One way to achieve this personal involvement is to link climate change to students' individual lives. Such a relationship can be created using a personal greenhouse gas budget, comprising all emissions caused by a student over one year. A personal greenhouse gas calculator was developed at the School of Physics, University of Sydney, in the form of a computer spreadsheet, and applied in university teaching. This calculator does not only address emissions from energy use, but also those emissions embodied in goods and services. Embodied emissions are often ignored when climate change is related to lifestyles. As its normative part, the calculator states a benchmark of 3.5 t CO_2 per person per year, based on the principle of global equity and sustainability. First experiences show that most students agree with that benchmark, and accept responsibility for embodied emissions. However, their own emissions results exceed by far the equitable and sustainable budget. This experience triggers various feelings, ranging from surprise and motivation, to guilt, denial, self-defence, cynicism, anger, and frustration. In contrast to a model where teaching is seen as transmission of information, this personal and provocative approach creates an emotional response, which affects memory, which in turn holds out the promise of long-term change.

Introduction

Climate change is one of the most pressing environmental problems today. Because of its long-term effects, it could have drastic consequences for future generations. The education of young people therefore plays a crucial role in grappling with the problem of reducing greenhouse gas emissions. It may be the global and therefore abstract nature of climate change that explains the lack of effective abatement by the main contributors—people in industrialised countries. To complicate matters, climate change is also linked to the problem of the considerable inequity between industrialised and developing countries. Environmental education needs therefore to concentrate on relating these global and abstract issues to students' personal realities, in other words, their lifestyles. In linking the global and the local it is hoped that students will gain a deeper understanding of the issues and translate their understanding into personal social, cultural, economic and political life-choices that will ultimately influence collective decision making through work, leisure and our various democratic systems of government.

This article is a follow-up of work published in a previous issue of this journal (Lenzen *et al.* 2000), where the authors analysed teaching and learning material about climate change available in New South Wales and Victoria, and concluded that three issues were neglected: (1) international emissions disparities and equity, (2) achievements of political and technological abatement and potential individual responses, and (3) responsibility for emissions embodied in goods and services. Consequently, subsequent work concentrated on incorporating these issues into an effective education tool that can link climate change with lifestyles: a personal greenhouse gas calculator. Such a calculator was developed at the School of Physics in the form of a computer spreadsheet, and applied in university teaching. Its main function is to translate lifestyles into greenhouse gas emissions. It addresses emissions from energy use and non-energy sources, and also emissions embodied in goods and services. As its normative part, the calculator states a benchmark of 3.5 tonnes of carbon dioxide equivalents[1] (t CO_2-e) per person per year, which is based on the principle of global equity and sustainability.

The following text provides information about the calculator and a case study of its use in a university teaching program. It is organised as follows: Sections 2 and 3 provide the scientific, political and social background of climate change, which motivated the development of the calculator, which is described in Section 4. As the main part of this article, Section 5 reports experiences from using the calculator as a provocative means of engaging a group of university students in learning about the issues surrounding climate change. Conclusions are drawn in Section 6.

Equity and sustainability in the context of climate change

The wealthy 20% of the world's population causes about three-quarters of global greenhouse gas emissions. Average per-capita emissions in North America, Australia, Europe or Japan are about ten times higher than those in South Asia or China (United Nations Department for Economic and Social Information and Policy Analysis 1996). The key factor for the level, distribution, and increase of global greenhouse gas emissions and for environmental degradation in general is the

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increasing material standard of living in the industrialised world (World Commission on Environment and Development 1987). The influence of population growth in the developing world on emissions is at present considerably lower (Parikh 1996). Paradoxically, while the South's population issues have been the subject of international negotiations on climate change, the North's unsustainable and unfair consumption has never been adequately acknowledged (Parikh *et al.* 1994, Hyder 1992, Kandlikar *et al.* 1999, Heil *et al.* 1997). It is therefore not surprising that the wealthy North is being accused of appropriating yet another global commons and thus exercising environmental colonialism (Agarwal *et al.* 1991).

The Intergovernmental Panel on Climate Change has acknowledged that 'the balance of evidence suggests a discernible human influence on the global climate' (Intergovernmental Panel on Climate Change 1995). Climate change is now considered to be one of the most serious threats to the environment (Watson *et al.* 1996). Models suggest that a stabilisation of atmospheric CO_2 concentrations at today's level can only be achieved through a reduction in net emissions by more than 50% in the next 40 years and further reductions thereafter. Even then, a global sea level rise of more than 25 cm is expected over the next 100 years (Houghton *et al.* 1997).

Apportioning the same right to emit to everybody on the planet and at the same time reducing emissions by 50% yields an equitable and sustainable greenhouse gas budget of about 3.5 t CO_2-e/cap (see Lenzen 1997, Byrne *et al.* 1998, and Royal Commission on Environmental Pollution 2000). In order to achieve international equity and sustainability, industrialised nations need to reduce emissions by about 85%, while developing nations can more or less remain at the present levels (Lenzen *et al.* 2000).

Linking lifestyles with responsibility for equitable and sustainable emissions

'Many in the South feel that climate change is an issue of lifestyles' (Kandlikar *et al.* 1999). In order to support the life of an average Australian, for example, about 25 t CO_2-e are emitted annually, which is more than seven times the equitable and sustainable level (Lenzen *et al.* 2000). About 20% of these emissions are caused by household energy and private car use, while the remaining 80% are required for the provision of consumer goods, and commercial and public services (Lenzen *et al.* 2000). In most industrialised countries, emissions are mainly driven by income growth (Mélanie *et al.* 1994, Hamilton *et al.* 1999), which affects greenhouse gas emissions in a stronger way than energy efficiency measures or fuel mix changes (Schipper 1998). Therefore, promoting lifestyle changes can effectively complement political and technological abatement measures that, on their own, do not seem to be achieving equity and sustainability (Trainer 1997).

Despite the fact that lifestyles play a key role for inequity and unsustainability of greenhouse gas emissions, they are often not addressed in information and education materials. Most school resources published in the Australian states of New South Wales and Victoria, and also many existing greenhouse gas calculators and scorecards, for example, do not mention goods and services consumption at all (Lenzen *et al.* 2000, see for example Environment Protection Authority Victoria 1992b, Environment Protection Authority Victoria 1992a, Environment Protection Authority Victoria 1994, Sustainable Solutions Pty Ltd 1996, Environment Australia 1997a, Tomalty 2000, Wright 2000, BHP Steel 2001, Environment Protection Authority Victoria 2001, see also Simmons *et al.* 1998, Best Foot Forward 2001). As a consequence, only household energy and private car usage are commonly perceived by Australians as areas of individual responsibility (Stokes *et al.* 1994, Australian Bureau of Statistics 1997). As a result, effective means of reducing greenhouse gas emissions through individual action such as sharing or borrowing household items, buying second-hand, or engaging in low resource-use activities, are foregone (Lenzen 2001).

'Despite the fact that lifestyles play a key role for inequity and unsustainability of greenhouse gas emissions, they are often not addressed in information and education materials'

While adults in general may be lacking in taking overt action for the environment, current research suggests that younger people are more likely to be more accepting of radical changes. A survey of South Australian school students showed that only about 20% thought that 'the only way to solve environmental problems is through scientific and technological means', but more than 80% believed that 'the ultimate solution for environmental problems depends on drastic changes in our life-style' (Worsley *et al.* 1998).

Public appeals for individual action have proven successful in cases where alternative, environmentally friendly products are available (for example ozone depletion). However, climate change is posing greater barriers to consumer action, because it requires 'rethinking [how to] achieve life satisfaction and express one's social status and personal worth' (Kempton 1993). It is therefore important that education resources address social values and personal participation and satisfaction.

A comprehensive personal greenhouse gas calculator

Educators can assist value shifts by demonstrating the relevance of lifestyle choices for greenhouse gas emissions. A simple yet powerful means to link the global problem of climate change with elements of individual lives is the idea of a personal greenhouse gas budget. A comprehensive personal greenhouse gas calculator in the form of an electronic spreadsheet was developed for Australia. Its design closely adheres to the following guidelines obtained from recent studies of consumer behaviour (De Young 1996, Brown *et al.*

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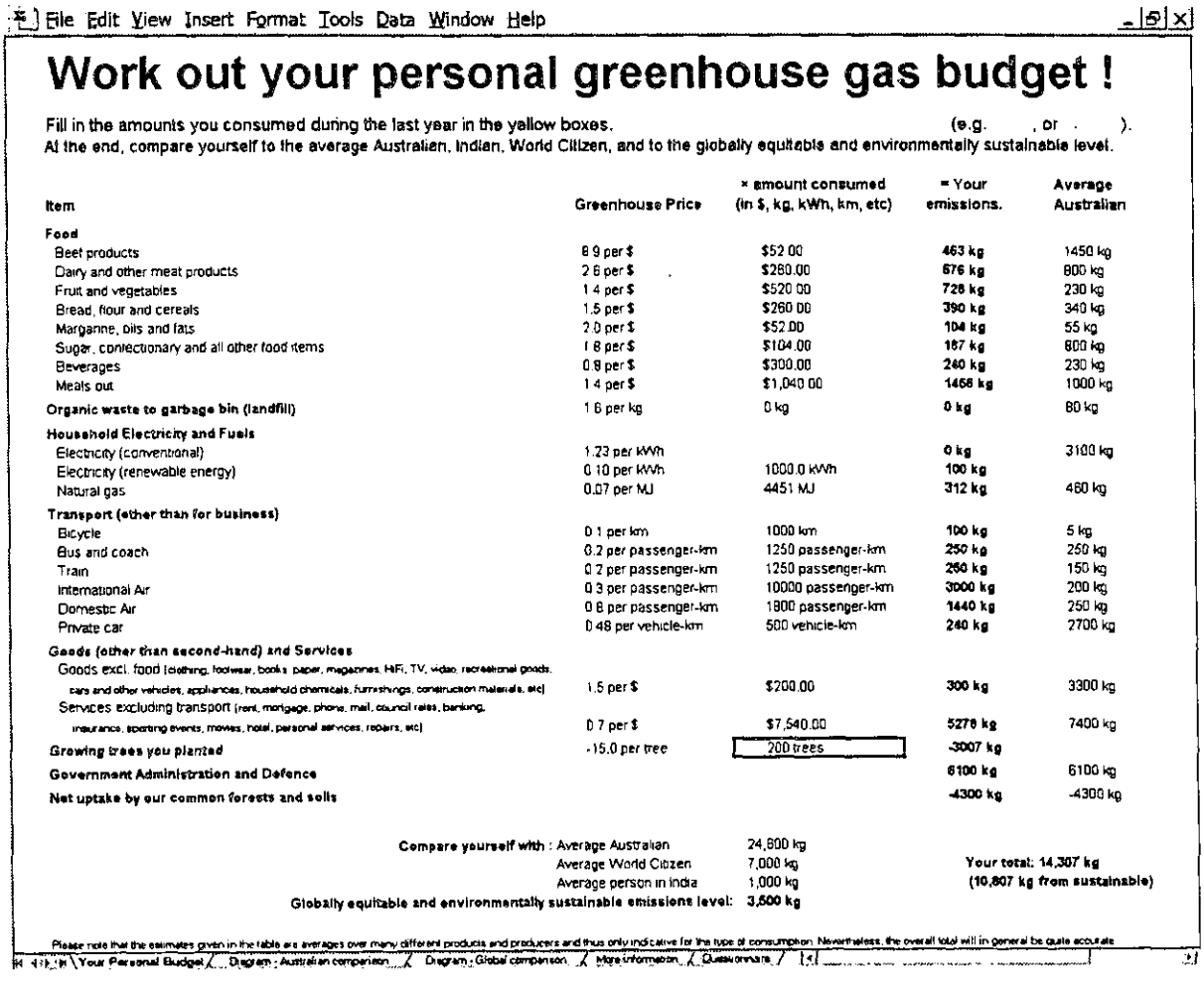
Figure 1: Budget worksheet of the personal greenhouse gas calculator (Lenzen *et al.* 2001a). The amounts entered represent the consumption of one of the authors



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Work out your personal greenhouse gas budget !

Fill in the amounts you consumed during the last year in the yellow boxes. (e.g. , or .).
At the end, compare yourself to the average Australian, Indian, World Citizen, and to the globally equitable and environmentally sustainable level.

Item	Greenhouse Price	× amount consumed (in $, kg, kWh, km, etc)	= Your emissions.	Average Australian
Food				
Beef products	8.9 per $	$52.00	463 kg	1450 kg
Dairy and other meat products	2.6 per $	$260.00	676 kg	800 kg
Fruit and vegetables	1.4 per $	$520.00	728 kg	230 kg
Bread, flour and cereals	1.5 per $	$260.00	390 kg	340 kg
Margarine, oils and fats	2.0 per $	$52.00	104 kg	55 kg
Sugar, confectionary and all other food items	1.8 per $	$104.00	187 kg	600 kg
Beverages	0.8 per $	$300.00	240 kg	230 kg
Meals out	1.4 per $	$1,040.00	1456 kg	1000 kg
Organic waste to garbage bin (landfill)	1.6 per kg	0 kg	0 kg	80 kg
Household Electricity and Fuels				
Electricity (conventional)	1.23 per kWh		0 kg	3100 kg
Electricity (renewable energy)	0.10 per kWh	1000.0 kWh	100 kg	
Natural gas	0.07 per MJ	4451 MJ	312 kg	460 kg
Transport (other than for business)				
Bicycle	0.1 per km	1000 km	100 kg	5 kg
Bus and coach	0.2 per passenger-km	1250 passenger-km	250 kg	250 kg
Train	0.2 per passenger-km	1250 passenger-km	250 kg	150 kg
International Air	0.3 per passenger-km	10000 passenger-km	3000 kg	200 kg
Domestic Air	0.8 per passenger-km	1800 passenger-km	1440 kg	250 kg
Private car	0.48 per vehicle-km	500 vehicle-km	240 kg	2700 kg
Goods (other than second-hand) and Services				
Goods excl. food (clothing, footwear, books, paper, magazines, HiFi, TV, video, recreational goods, cars and other vehicles, appliances, household chemicals, furnishings, construction materials, etc)	1.5 per $	$200.00	300 kg	3300 kg
Services excluding transport (rent, mortgage, phone, mail, council rates, banking, insurance, sporting events, movies, hotel, personal services, repairs, etc)	0.7 per $	$7,540.00	5278 kg	7400 kg
Growing trees you planted	-15.0 per tree	200 trees	-3007 kg	
Government Administration and Defence			6100 kg	6100 kg
Net uptake by our common forests and soils			-4300 kg	-4300 kg

Compare yourself with :	Average Australian	24,800 kg	
	Average World Citizen	7,000 kg	**Your total: 14,307 kg**
	Average person in India	1,000 kg	**(10,807 kg from sustainable)**
Globally equitable and environmentally sustainable emissions level:		**3,500 kg**	

Please note that the estimates given in the table are averages over many different products and producers and thus only indicative for the type of consumption. Nevertheless, the overall total will in general be quite accurate.

Your Personal Budget | Diagram : Australian comparison | Diagram : Global comparison | More information | Questionnaire

2000), and from experiences with an environmental household account project (Lund 1998) and with existing consumer guides (Hofstetter 1992, Schlumpf *et al.* 1999, Mackay *et al.* 2000). Its features include:

- It is easily accessible (Internet site http://www.physics.usyd.edu.au/apphys/greenhouse/greenhouse.html, downloadable files).
- It contains a short, easy-to-handle personal budget sheet (Fig. 1), which provides direct feedback through instantaneous budget re-calculation after each change of entry.
- It contains a normative part (equity and sustainability) and states a benchmark (3.5 t CO_2-e).
- It contains comparisons and graphical presentations (Figs. 2 and 3).
- It contains a short, easy-to-read explanation of the problem and its importance, strategies for action, and a reference for further information (Fig. 4).
- The normative part and action strategies foster pro-environmental values by referencing to social norms (fairness, conservation) and by promoting a creative life instead of earning and consuming, or low resource-use instead of high resource-use activities.
- It suggests debates and activities that raise the issues of quality of life and consumption and help students to make comparisons (through research and direct contact with students in other countries) and informed choices about local action.
- It motivates reduced consumption through intrinsic satisfaction. This satisfaction is brought about by direct participation, that is, in allowing users to find their own areas, reasons, and procedures for conserving behaviour, and to become interested in the task and challenged by the benchmark.
- It underwent an independent peer review and was 'test-run' by non-academic users.

The main task of the calculator is to translate lifestyles into greenhouse gas emissions. This can be achieved by multiplying amounts of personal consumption of various items with corresponding 'greenhouse prices', thus arriving at personal emissions. These calculations are presented in form of an automatically updated spreadsheet with boxes for user entries (Fig. 1). Greenhouse prices for the consumer items were derived from Lenzen *et al.* 2001b (food, conventional electricity, gas, goods and services), Environment Australia

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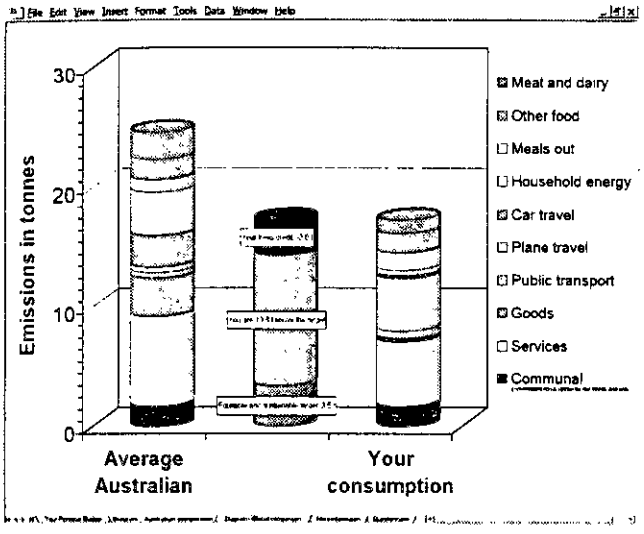
1997b (organic waste), Lenzen 1999a (renewable electricity), Lenzen 1999b (transport), and Australian Academy of Science 1995 (trees). Average Australian emissions were calculated from these greenhouse prices and consumption data in the Australian Household Expenditure Survey (Australian Bureau of Statistics 1995).

Figure 2: Worksheet 'Australian comparison' (Lenzen *et al.* 2001a)



The idea of budgeting personal greenhouse gas emissions was made public during a radio show on the Australian Broadcasting Corporation's (ABC) *Earthbeat* program (Internet site http://www.abc.net.au/rn/science/earth/stories/s1546.htm). A first version of the calculator was trialed in the form of a two-page handout (budget and information sheets only) on World Sustainable Energy Day on 4 March 1999 during a renewable energy exhibition event at Sydney Town Hall. Most people introduced to the handout at the School of Physics information stall felt in some way responsible for emissions that were caused by their goods and services consumption, a fact which motivated further development. First comments and suggestions from interested readers were received in response to a submission of the calculator to a Senate Inquiry into Australia's response to global warming (Senate Environment Communications Information Technology and the Arts References Committee 2000), and following newspaper articles (Crabb 2000). The calculator was then trialed once more, this time in the form of an electronic worksheet, by about 90 2nd and 3rd-year university students, the majority of whom were enrolled in Environmental Science courses at the University of Sydney. The gender split in these students is approximately 45% female, 55% male. Although filling out the calculator and answering the questionnaire was not compulsory for the environmental science students, the response rate was almost 100%. Energy, greenhouse gas emissions and global equity issues were discussed in a dedicated lecture, prior to the calculator being made available to students. This lecture was part of a series dealing with atmospheric physics, climate change, and renewable energy issues. Students returned their completed calculator and questionnaire within a few weeks of the equity lecture. The results presented here are from this

Figure 3: Worksheet 'Global comparison' (Lenzen *et al.* 2001a)

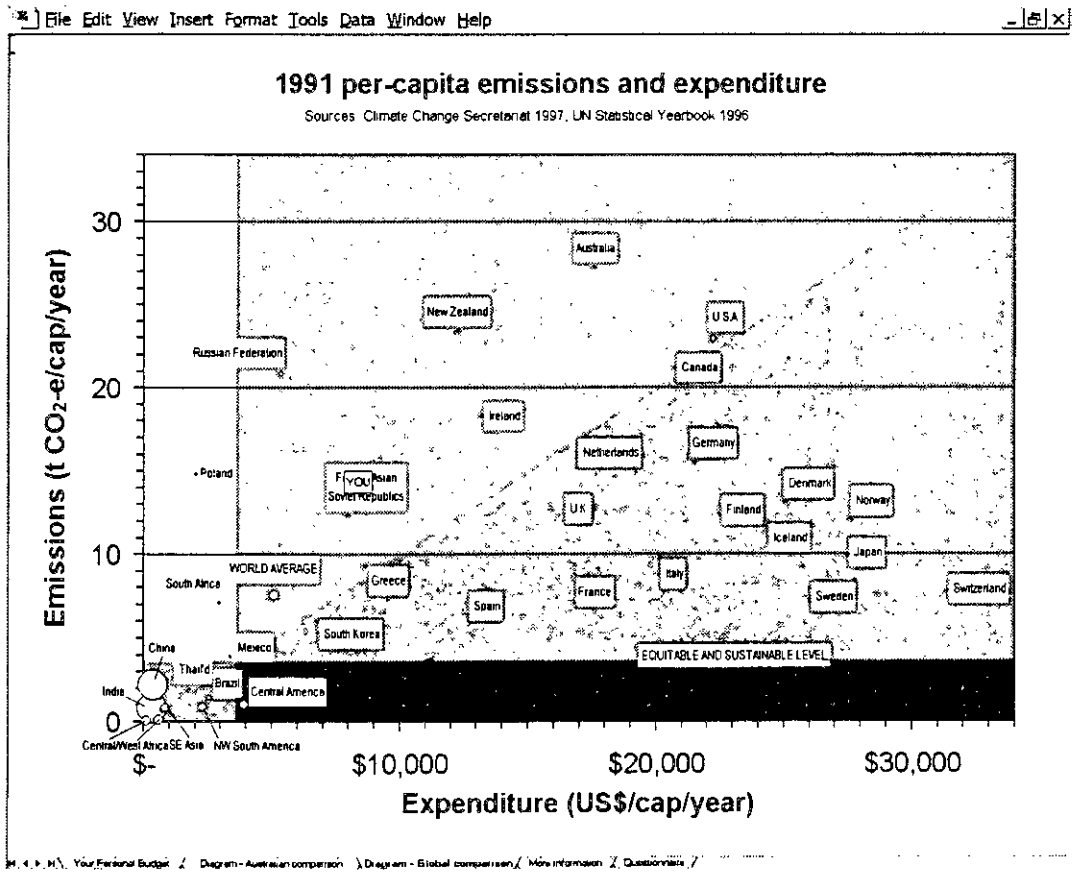


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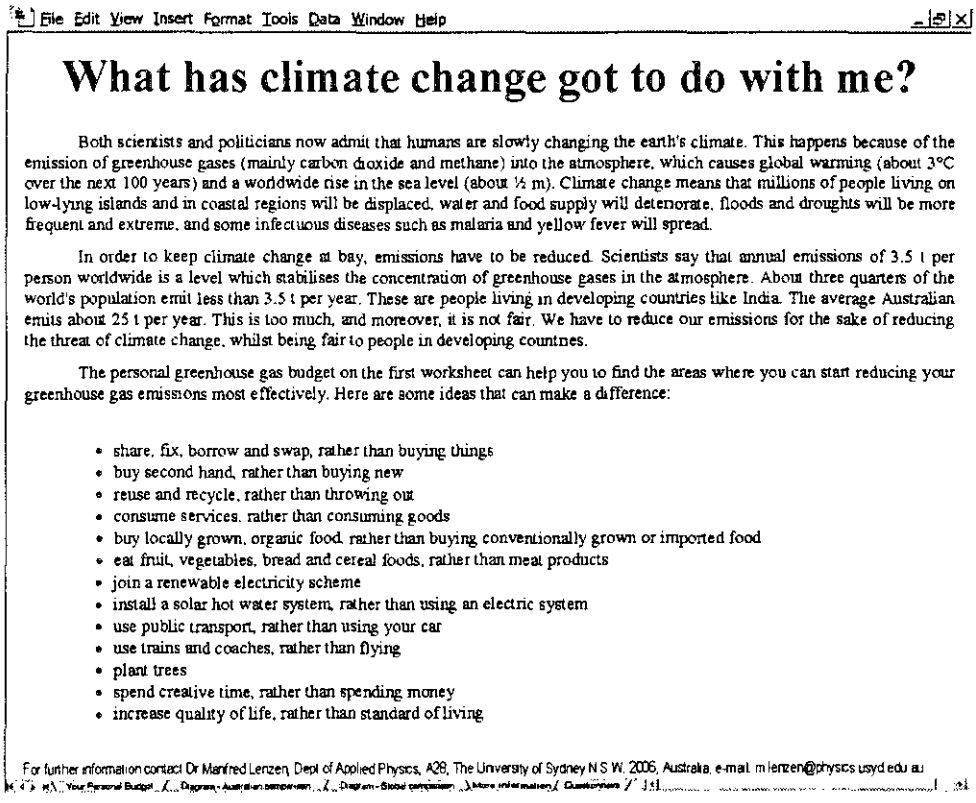
Figure 4: Worksheet 'More information' (Lenzen *et al.* 2001a)



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What has climate change got to do with me?

Both scientists and politicians now admit that humans are slowly changing the earth's climate. This happens because of the emission of greenhouse gases (mainly carbon dioxide and methane) into the atmosphere, which causes global warming (about 3°C over the next 100 years) and a worldwide rise in the sea level (about ½ m). Climate change means that millions of people living on low-lying islands and in coastal regions will be displaced, water and food supply will deteriorate, floods and droughts will be more frequent and extreme, and some infectuous diseases such as malaria and yellow fever will spread.

In order to keep climate change at bay, emissions have to be reduced. Scientists say that annual emissions of 3.5 t per person worldwide is a level which stabilises the concentration of greenhouse gases in the atmosphere. About three quarters of the world's population emit less than 3.5 t per year. These are people living in developing countries like India. The average Australian emits about 25 t per year. This is too much, and moreover, it is not fair. We have to reduce our emissions for the sake of reducing the threat of climate change, whilst being fair to people in developing countries.

The personal greenhouse gas budget on the first worksheet can help you to find the areas where you can start reducing your greenhouse gas emissions most effectively. Here are some ideas that can make a difference:

- share, fix, borrow and swap, rather than buying things
- buy second hand, rather than buying new
- reuse and recycle, rather than throwing out
- consume services, rather than consuming goods
- buy locally grown, organic food, rather than buying conventionally grown or imported food
- eat fruit, vegetables, bread and cereal foods, rather than meat products
- join a renewable electricity scheme
- install a solar hot water system, rather than using an electric system
- use public transport, rather than using your car
- use trains and coaches, rather than flying
- plant trees
- spend creative time, rather than spending money
- increase quality of life, rather than standard of living

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case study of the calculator used in teaching. At the time of trial at the University of Sydney, the calculator was included in the NSW Department of Education and Training's TILT Plus Science teacher development program as an important area for teacher investigation (Lenzen *et al.* 2001a). In 2002, it was licensed to the ABC for inclusion in *ABC Science Online—The Lab* (http://www.abc.net.au/science).

First experiences: Getting beneath the surface

In order to obtain first impressions on the topic and feedback on the design of the calculator, the questionnaire shown in Fig. 5 was circulated amongst the environmental science students described above, and their responses evaluated. The statements listed in Section A of the questionnaire relate to issues in the current national and international debate on climate change. They were chosen to address some controversial questions such as: what are appropriate emissions baselines? (A1), and who should take on and/or pay for emission reductions? (A2, A4). Statement A3 was chosen because government administration is an item on the calculator spreadsheet (see Fig. 1). Section B aims at appraising the effect the calculator had on users. Statements B1 and B2 relate to particular features of the calculator, which are often not mentioned in learning and information material (see Lenzen *et al.* 2000), that is, the quantification of equity and sustainability in the context of climate change, and the focus on personal emissions. The following Sections document results from both completed calculator spreadsheet and questionnaires.

Note that the survey was carried out to improve teaching in the Environmental Science courses at the University of Sydney, and that the students were selected for that reason only. This investigation therefore has the character of a case study rather than a general methodological inquiry, and the results documented below refer primarily to this particular teaching situation.

Greenhouse gas budgets

Fig. 6 shows the relationship between annual expenditure and greenhouse gas emissions for respondents from three environmental science courses taught at the School of Physics (_) and representative Sydney households (_). All respondents exceed the equitable and sustainable level of 3.5 t CO_2-e. Obviously, the consumption of the Environmental Science students occurs at lower incomes than that of the average Sydney population. Interestingly, it appears to be causing slightly less greenhouse gas emissions per dollar spent at annual expenditures above 15,000 A$ than that of the representative sample of the Sydney population. This circumstance causes the emissions-expenditure function representing the students' lifestyle to flatten out towards higher expenditures, which is quantified by the *elasticity* $\eta = (dE/E)/(dX/X) = 0.61$ of the curve, which is lower than that for the representative sample of the Sydney population (η=0.79). This result indicates some conscious choice as to their consumer basket, and hence that the students are not representative of the Sydney population with regard to their attitude to environmental issues.

There are two qualifications to these results: firstly, since most undergraduate students live at home with their parents, it may be that they are not fully aware of all the expenditures required to maintain their lifestyles. Secondly, since most students live

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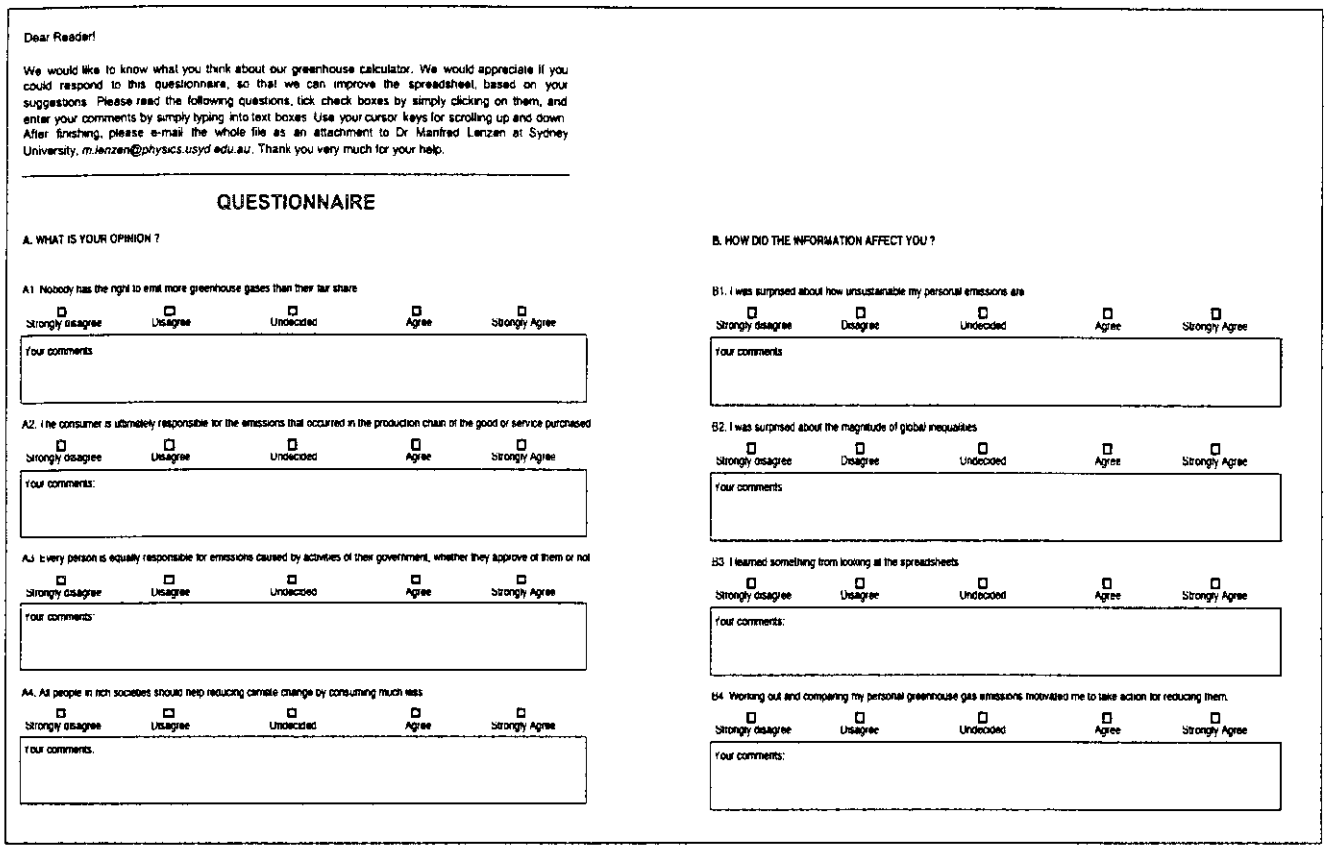
Figure 5: Questionnaire accompanying the personal greenhouse gas calculator



Dear Reader!

We would like to know what you think about our greenhouse calculator. We would appreciate if you could respond to this questionnaire, so that we can improve the spreadsheet, based on your suggestions. Please read the following questions, tick check boxes by simply clicking on them, and enter your comments by simply typing into text boxes. Use your cursor keys for scrolling up and down. After finishing, please e-mail the whole file as an attachment to Dr Manfred Lenzen at Sydney University, *m.lenzen@physics.usyd.edu.au*. Thank you very much for your help.

QUESTIONNAIRE

A. WHAT IS YOUR OPINION ?

A1. Nobody has the right to emit more greenhouse gases than their fair share

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

A2. The consumer is ultimately responsible for the emissions that occurred in the production chain of the good or service purchased

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

A3. Every person is equally responsible for emissions caused by activities of their government, whether they approve of them or not

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

A4. All people in rich societies should help reducing climate change by consuming much less

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

B. HOW DID THE INFORMATION AFFECT YOU ?

B1. I was surprised about how unsustainable my personal emissions are

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

B2. I was surprised about the magnitude of global inequalities

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

B3. I learned something from looking at the spreadsheets

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

B4. Working out and comparing my personal greenhouse gas emissions motivated me to take action for reducing them.

☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly Agree

Your comments:

in a family home, their household size exceeds that of the Sydney average, leading to lower per-capita emissions (compare Lenzen *et al.* 2001b).

Opinions about responsibility

Figs. 7 and 8 contain frequency histograms of the responses to parts A and B of the questionnaire reproduced in the Appendix.

Fig. 7 shows that the issue of responsibility for industrial emissions was controversial. Students who felt responsible did so mostly because they thought it was their choice to consume or not. Disagreeing students pointed out that consumers had either little product choice and/or insufficient knowledge about the complex environmental consequences of their selection:

> '... producers also have a great responsibility, especially because they know what they do and what they could do ...'

> '... I don't KNOW the entire production chain of every good or service—and I don't have enough hours in my life to find out all those things!'

> 'I would agree with this if it was made plain just what effect and cost to the environment any particular [good or service] had ...' .

Equally controversial, but more undecided, was the reaction to allocating responsibility for government activities to the citizen. While the questionnaire addressed government expenditure for the general public, such as for unemployment benefits, public transportation, health care, education etc, respondents' were influenced by whether they voted for the government in power and/or whether this government was performing to their expectations:

> 'If you did not vote for a particular government, and are actively involved in lobbying for changes to policy how can you be responsible/accountable for government emissions?'

> 'I would prefer that my government is more responsible than I know them to be—but there are other pressing issues [...] including child care, education, elder care [...], employment ...'

> 'Individuals can bring pressure on the government of a country to change their policies, but the fact that a government continues in power with policies that are harmful to the environment proves that the majority of the population gives (at least tacit) approval of those policies. I don't think that means the concerned minority are "responsible" for what they haven't been able to achieve against such opposition'.

> '... in the case where you strongly disagree with a response where community apathy is unlikely to force the government to change its mind, it is hard to see how that responsibility can be fully shared ...'

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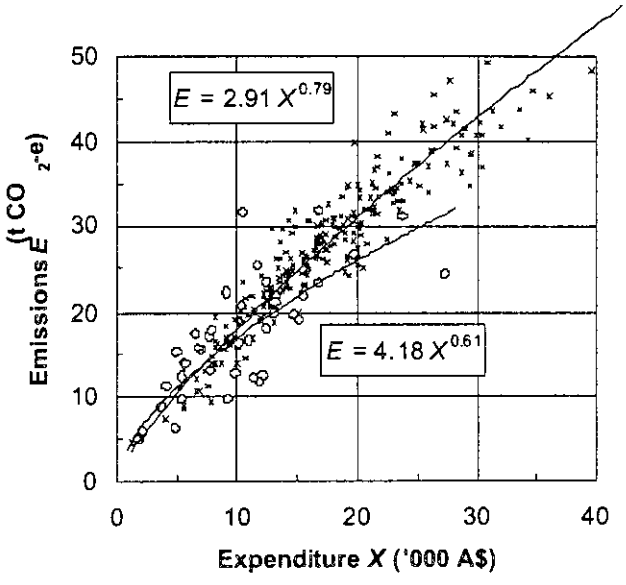
Figure 6: Relationship between annual expenditure and greenhouse gas emissions for respondents from two Environmental Science courses (_) and representative Sydney households (_).



Opinions about and reaction to equity and sustainability

Most students agree with the notion of a 'fair share' in terms of greenhouse gas emissions, and the support for consumption reductions of the affluent is even higher (Fig. 7). Similarly, most students were not surprised about global inequities (Fig. 8):

> 'I have long known the massive inequality inherent in a world driven by our basic desires (greed)'.

Notwithstanding, the majority of the same students were surprised about their *own* unsustainability, albeit being members of an affluent industrialised society. This result indicates the ineffectiveness of a teaching model that relies on the transmission of information, even if this teaching relates to ethical issues such as global equity. The personal approach taken by the greenhouse gas calculator obviously evoked feelings related to issues that were not addressed by learning material previously accessed by the students:

> '... I was shocked by the very blunt graphic that compares "you" with the rest of the world'.

> 'It is good to actually be able to figure out how much I emit'.

> '... this test alone has filled up some gaps in my knowledge & identified some points I'd like to improve'.

> 'The sustainable average figure is a new concept ...' .

It also triggered criticism and discourse:

> 'It is depressing though, that you include our trees and soils as negative influences. Does this mean that those in land locked desert countries have less right to consume than I do as they have less counteractions? I certainly hope not, or people will forget that things like the Brazilian rainforest helps globally not just locally'.

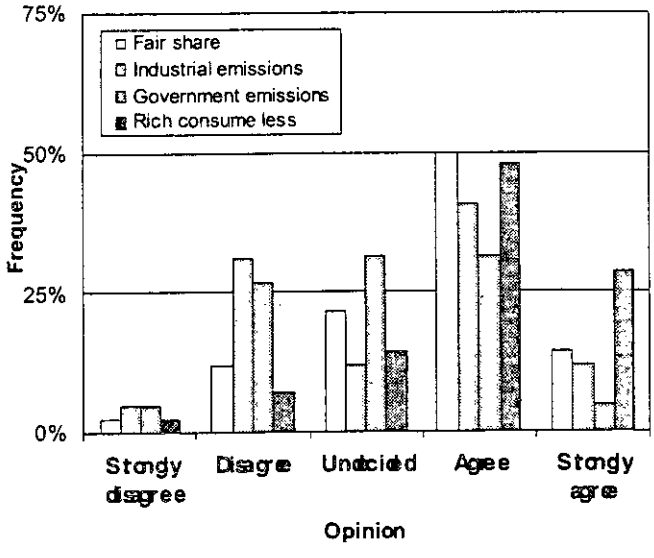
> 'Oversimplification, what about overseas experts helping less developed countries improve their performance. International travel is dealt with very harshly in this study ... The use of 2nd hand materials and recycling does not appear as a credit in any place'.[2]

> '... I think it would probably be a little more accurate if it split some items up. As an example, I believe (tell me if I'm wrong) that some cleaning products have a lower detrimental effect than others. I tend to only use laundry soap, vinegar, etc instead of the usual laundry detergents, etc. Also, surely organically produced food products would have a lower greenhouse gas emission index than normally produced foodstuffs?'[3]

One respondent hinted at the fact that we are immersed in our society, and that we are not necessarily thinking about the living conditions in other parts of the world:

> 'Interesting to see how personal consumption that I thought was sustainable only seems that way compared to the rest of Australia but not the world'.

Figure 7: Frequency histogram of the responses to part A (opinion) of the questionnaire



Learning impact and motivation

Respondents were almost unanimous in confirming that they had learned something from using the calculator. However, using the calculator evoked a whole range of feelings, ranging from motivation and participation:

> 'I think it has identified some places where I can make better choices and/or reduce usage'.

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surprise and discomfort:

> 'I was very surprised when I had completed the questionnaire about my own personal usage habits to see that I'm using more than I had realised... and uncomfortably aware that it seems also to be more than my fair share'.

to self-defence:

> '... And my daughter and I DO try to consume less... sometimes I have to bring my car to work, but from April through October, I take my bike as much as possible. If I could carpool, then I would do that as well... I have moved closer to my work and my school so that even if I do use the car, I use it less. I don't use paper towels, because I can use cloths or tea towels... I don't use plastic wrap and as much as possible store things in existing containers (recycling glass jars, for instance; or using containers in which goods were originally purchased),'

criticism and denial:

> 'Rights are an illusion. However, in the same way that we don't have the "right" to pollute more than our fair share, we also have the "right" to increase our standard of living'.

> 'I didn't bother trying to guess as it would not even be in the ball park. I wonder who has these figures where this was developed, and how much of their life is consumed with statistics. Have many people tried to fill it in?'

> 'I have to be undecided on this, as strongly disagreeing because I already knew of the figures would be misleading'.

guilt and frustration:

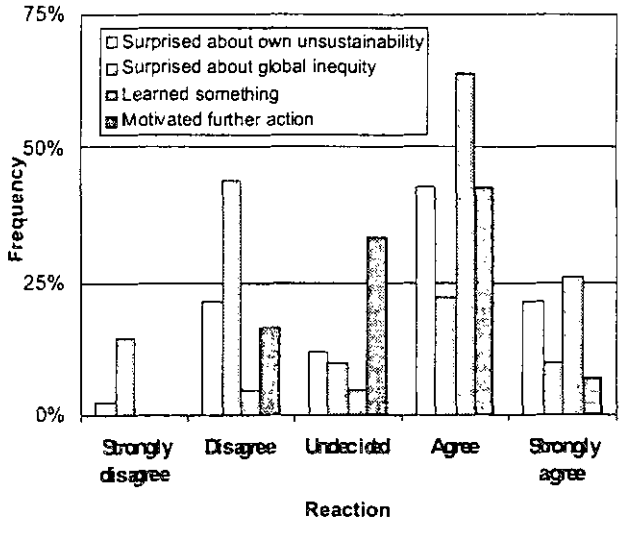
> 'I mostly felt guilty'.

> 'It's depressing, really... but it will make me pay more attention, I know'.

Several respondents said that the background information and suggestions provided with the calculator were not useful, and that they should be more practical and contain details about alternative diets, where to get organic produce, or how to join a renewable energy scheme. One respondent, who also thought critically about personal responsibility for government emissions, pointed out the role of leadership in government:

> 'Individual action on such collective issues is often frustrating. The harder you try to live more sustainably, the more you notice the huge majority who are ignorant of, or simply ignore the problem. I believe that government coercion through such channels as hyper-inflating energy prices and punitive taxation on unsustainability, is required to make any real difference to the Australian psyche, and the world environment'.

Figure 8: Frequency histogram of the responses to part B (reaction) of the questionnaire



Interestingly, government intervention in non-sustainable lifestyles has been discussed previously in the Netherlands (Beekman 1997)[4]. Whether the calculator created motivation for further action was less clear:

> 'In practice it seems difficult to give up a certain lifestyle, e.g. not travelling ...'

> 'I try to reduce my impact in many ways, but find it increasingly difficult. There is of course no support from those who profit most from environmental exploitation ...'

> 'Most of what we read about products is put out by those who produce them'.

These responses show that individual awareness and concern are a prerequisite for, but do not necessarily lead to changes towards more sustainable lifestyles. Trust in information sources, institutional and infrastructural support, response knowledge, and belief in the efficacy of pro-environmental behaviour are only a few of the conditions for translating awareness into corresponding action (compare Eden 1993, Kempton 1993, Harrison *et al.* 1996, Hinchliffe 1996). Moreover, compared to issues where pro-environmental behaviour is relatively easy (for example buying CFC-free products, or other 'environmentally friendly' substitutes), reducing greenhouse gas emissions appears to be a more difficult task, because it involves people's status and worth in their social network, and the life satisfaction derived from that (compare Kempton 1993 and Bennulf 1997):

> 'I try to be good at these things, but it really is a matter of fitting in. Ideally I would do more, but often in the

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society we are faced with (or born into) gives us little opportunity for variation'.

Conclusions

Using the personal greenhouse gas calculator in our teaching stimulated interesting and controversial discussions about ethical topics such as equity and responsibility. These topics had also been part of previous lectures given to environmental science students. However, anecdotal evidence suggests that these lectures did not generate a comparable response from the students. It is possible that this cohort of students, with an above average knowledge of climate change issues, are to some extent saturated with teaching materials. A personal approach, facilitated by the calculator, seems to renew their interest in this issue. It is our belief that learning about issues involving global equity could be enhanced by not only conveying information about the *topic*, but by also in a more personal way relating the *lives* of people in other countries to those of the students.

Teaching directed towards promoting more sustainable lifestyles should still respect the freedom of the individual to live their lives as they wish, and allow students to find their own areas, reasons, and procedures for conserving behaviour. The personal greenhouse gas calculator presented in this article addresses a broad range of action, targeting not just energy use, but all aspects of consumption. In this respect, we believe that it represents an improvement over previous educational tools.

Evaluating the students' responses showed, however, that the recommendations for reducing greenhouse gas emissions in our calculator have to provide more response knowledge (for example about green power schemes), and avoid creating the image of a call for abstinence ('suggest good alternatives, don't just say "don't do this!"'). Moreover, they should further aim at supporting belief in the efficacy of personal action on a wider scale, and address the lack of trust in the attitudes of fellow citizens, producers, and the government. Finally and most importantly, they must deal a problem which was implicit in many of the questionnaire responses: how students can make significant lifestyle changes, while at the same time maintaining their status and worth in their social networks.

Nevertheless, in contrast to a model where teaching is seen as transmission of information this personal and provocative approach towards teaching about climate change created strong emotions that—whether negative or positive—we hope will ultimately lead to better learning.

Notes

1 The combined effect of all greenhouse gases is expressed in terms of the equivalent concentration of carbon dioxide, which would produce the same effect.

2 These comments were considered in the most recent version of the budget worksheet shown in Fig. 1.

3 The calculator in its present form is based on broad product groups and does not accommodate environmentally conscious choices. For example, the primary energy required to produce and deliver one kilogram of tomatoes has been calculated (Gysi *et al.* 1990) to 2 MJ for natural cultivation, 55 MJ for greenhouse cultivation, and 168 MJ for imports (in this case from the Canary Islands to Switzerland). To evaluate these differences for a whole range of products is a time- and labour-intensive task.

4 Beekman (1997) discusses four strategies: (1) coercion, (2) communication, addressing citizens with regard to their attitudes, (3) economic measures, addressing behaviour, and (4) institutional change, 'creating conditions for the re-shaping of lifestyles by citizen-consumers themselves'. Beekman concludes that the fourth strategy agrees most with the present division of responsibility between the government and the citizens in the Dutch society, and that it shows the most respect for the freedom of the individuals to live their lives as they wish.

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