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Publication details

Post-print of: Rodríguez, M, Boyes, E, Stanisstreet, M, Skamp, K, Malandrakis, G, Fortner, R, Kilinc, A, Taylor, N, Chhokar, K, Dua, S, Ambusaidi, A, Cheong, I, Kim, Y & Yoon, HG 2011, 'Can science education help to reduce global warming? an international study of the links between students' beliefs and their willingness to act', *International Journal of Science in Society,* vol. 2, pp. 89-100.
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THE INTERNATIONAL
JOURNAL
of SCIENCE
IN SOCIETY

Volume 2

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THE INTERNATIONAL JOURNAL OF SCIENCE IN SOCIETY
http://science-society.com/journal/

First published in 2011 in Champaign, Illinois, USA
by Common Ground Publishing LLC
www.CommonGroundPublishing.com

ISSN: 1836-6236

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Typeset in Common Ground Markup Language using CGPublisher multichannel typesetting system
http://www.commongroundpublishing.com/software/

Can Science Education Help to Reduce Global Warming?: An International Study of the Links between Students' Beliefs and their Willingness to Act

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Abstract: In this period of environmental degradation it is essential to assist people to change their attitudes, motives, skills and behaviors towards more sustainable ones. Education is one of the tools that might be expected to contribute towards achieving that goal. Unfortunately, however, few educational programs have had substantial impacts on people's actions for environment involvement (Jakobsson, Mäkitalo, and Säljö, 2009). One of the factors that underlie the 'gap' between knowledge and action (Kollmus and Ageyman, 2002) seems to be the disparity between general pro-environmental attitudes and values, and the specific motives and intentions needed to undertake the actions. So, in our research program we have examined links between beliefs about the usefulness of specific actions and the willingness to undertake those concrete actions. Questionnaires were completed by 12,627 school students in 11 countries, including Spain. Here we concentrate on students' views about modifying their methods of personal transport to reduce global warming. The relationships between students' Believed Usefulness of Action and their Degree of Willingness to Act were quantified by constructing indices to measure the extent to which enhancing a person's belief in the effectiveness of an action might increase their willingness to undertake it. Comparison of the values of this index for different actions and across different countries identifies those actions for which education is likely to produce behavior change.

Keywords: Cultural Differences, Environmental Action, Environmental Education, Global Warming

The International Journal of Science in Society
Volume 2, 2011, http://science-society.com/journal/, ISSN 1836-6236
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Introduction

WE LIVE IN a period characterized by environmental degradation. The extensive environmental disequilibrium we have already caused is threatening our social and physical wellbeing (IPCC, 2007), jeopardizing macroeconomic stability and security (Stern, 2007), and exacerbating border conflicts and migration problems (Solana, 2008). This environmental damage can be considered as three major problems: climate change caused by global warming (GW), the peak of oil production, and limits to growth (Hick, 2010). These problems, far from diminishing, appear to be growing, and at an increasing rate. For this reason it has been suggested that our situation can be seen as a 'planetary crisis' (Bybee, 1991). As a consequence it is necessary to behave with urgency and responsibility, to change our developmental patterns towards more sustainable ones.

In order to achieve such developmental change in the context of GW, it is necessary to persuade individuals to reduce their greenhouse gas contributions, because it is individuals who perform many of the actions that are environmentally significant (Jensen and Schnack, 2006). Although there are controversies about the aims of environmental education, it can be argued that education is one of the tools that can help people to change behaviors, motives and attitudes, and to develop skills and knowledge that allow individuals to make informed and rational environmental decisions in the light of various factors (Edwards, Gil, Vilches and Praia, 2004). So it is reasonable to expect that a well-developed educational program may engender in students a preparedness to act in more environmentally sympathetic ways (Jurin and Fortner, 2002).

Unfortunately, many of the environmental educational programs developed during the last decade have not succeeded in the way we might have expected (Jakobsson, Mäkitalo, and Säljö, 2009). This is because there are many factors that influence behavior patterns. These include social norms (Cialdini, Reno and Kallgren, 1990), physical facilitators and inhibitors (Coraliza and Berenguer, 2000), motives for community involvement (Batson, Ahmad and Tsang, 2002) and situational influences such as perceived self-efficacy (Devine Wright, Devine Wright and Flemming, 2004). Each of these mediator agents might have different influences on behavior, according to the pro-environmental action being considered and the interaction with the other agents. Some of these factors have been incorporated into models of behavior change (Kollmus and Ageyman, 2002 *inter alia*). One aspect that has emerged is that the link between *general* environmental attitudes, such as eco-friendliness or concern about eco-problems, and concrete or *specific* environmental behaviors is weak. To circumvent this weak relationship between *general* attitudes and *specific* behaviors, we have selected a particular segment of the complex relationship between knowledge and action, that is the specific relationship between the belief in the usefulness of some specific actions and the intentions to undertake these actions. In other words, we have attempted to study the extent to which belief in the effectiveness of one action influences the willingness to undertake that action.

Because of the nature of the influences on behavior, it is likely that the strengths of the incentives and disincentives even to specific pro-environmental actions will differ in different cultures and so might be quite dissimilar in different countries. An appreciation of these variations is important because individuals in many countries will need to play a role in reducing carbon emissions if global warming is to be reduced. For this reason, although the study was initiated in the UK, it has since been extended to a number other countries; these

countries present different social and cultural contexts. Thus, our research was designed to address a number of research questions:

1. To what degrees do students intend to undertake certain specific pro-environmental actions? We have termed this measure the *Degree of Willingness to Act*.
2. To what extents do students believe that various specific actions would reduce global warming? We have termed this measure the *Believed Usefulness of Action*.
3. To what extent are there quantitative links between the *Degree of Willingness to Act* and the *Believed Usefulness of Action*? Since such relationships might indicate changes in practices that may be wrought by increasing the belief that a specific action is useful, it can provide a measure of the *Potential Effectiveness of Education* in terms of increasing pro-environmental practice.
4. What differences exist, if any, between these measures and indices between students in different countries?

Thus, the results of this study enable us to explore whether the degree of readiness to undertake a specific pro-environmental action might be influenced by education about the usefulness of the actions, for different actions and for different countries.

Methods

In this international study we have used a closed-form questionnaire originally developed by Boyes and Stanisstreet for British population (Boyes, Skamp and Stanisstreet, 2009); this was adapted for use in the different languages. The questionnaire was first translated into the appropriate language and then back-translated, independently, into English. The back-translation was checked by the English authors to ensure the integrity of the translation. At the same time the content validity of the questionnaire was examined according to the local context by environmental experts of each country.

The questionnaire was fronted by a coversheet where participants provided their age, grade and gender. The main body of the questionnaire was in two sections. In the first main section the participants were asked about their intentions to undertake specific pro-environmental actions; these items evaluated the students' *Degree of Willingness to Act*. Each of the items here had a realistic qualifying phrase, such as 'Even if it was not as fast or luxurious, I would try to get a car that uses less petrol or less diesel' or 'Even if it took me longer and was more inconvenient, I would try to use buses and trains instead of a car'. There were 20 such items in this section of the survey; four were distracters, and the remaining 16 concerned actions that are generally accepted as having some effect on global warming. The items covered four themes: energy efficiency in the home, power generation, indirect action by voting for certain policies, and personal transport. The last theme is considered here.

The second major section of the questionnaire explored students' perceptions of the extent to which specific actions would contribute to a reduction in GW; these items were to determine students' *Believed Usefulness of Action*. There were also 20 items in this section, and these were paired with the items in the first section. For example, the first item exemplified in the preceding paragraph was paired with a question 'If people had smaller cars that used less petrol or less fuel, Global Warming would be reduced…' and the second item with the question 'If people didn't use their cars so much, Global Warming would be reduced…'. In the actual questionnaire, the items in the first and second major sections were in a different

order so that the pairing was not immediately obvious to the respondents. Just as the items in the two sections were covertly *paired*, so the wording of the response options was designed to be semantically and numerically *matched* (Table 1). This allowed relationships to be quantified between the degree to which a student would be likely to take an action and the extent to which they believed it had a beneficial effect in reducing GW.

The final part of the questionnaire consisted of four questions to evaluate students' beliefs about the reality of GW, their concern about GW, how environmental friendly they thought they were, and how much they considered they knew about this GW.

12,627 students aged 11 to 18 years participated in the research; they were in 11 different countries around the world (Tables 2 and 3). The questionnaire was administered in routine classes by students' normal classroom teachers or by one of the researchers, and students were assured that the results would be anonymous.

Results

In order to set the main results in context, some responses from the final section of the questionnaire will be considered first. Some 73% of the participants believed that GW is happening now, although that belief was stronger in some countries than in others. For example, 92% of the participants of Turkey thought that GW is happening, while almost 40% of the British participants are unsure about it. In general, students in the Anglo-Saxon countries and Greece were less sure about the reality of GW, compared with those in Turkey and the oriental countries.

The results for the two main sections of the questionnaire for the two transport actions were broadly similar so, for brevity, 'transport actions' in general will be discussed. For both actions, the use of public transport rather than a private car and the use smaller cars that emit less carbon dioxide, most of the participants from all countries believe that these actions are effective in reducing GW. That is, students appear to have a high *Believed Usefulness of Action*. Many students from some countries such as India, Turkey, Brunei and Singapore also had a high *Degree of Willingness to Act*; that is, they expressed an intention to undertake these actions. In contrast, fewer students - less than half - from other countries such as the UK, the USA, Australia and Greece were willing to use smaller cars or public transport. So, for some countries there is a correspondence between students' belief in the usefulness of the actions and their willingness to act, but for other countries that correspondence is weaker.

In order to explore this further, various novel indices were calculated to determine the relationships between students' *Degree of Willingness to Act* and their *Believed Usefulness of Action* for specific actions. For example, the value for the *Degree of Willingness to Act* for an action was plotted against the value of the *Believed Usefulness of Action* for the same action, and a regression line was fitted. Regression of these ordinal variables is made more acceptable in statistical terms by the fact that the scales have been semantically and numerically matched. The slope of the line represents a measure of the *Potential Effectiveness of Education*, in the context of reducing of global warming. That is, it indicates the amount by which strengthening students' beliefs that an action is effective might increase their willingness to undertake that action. An action that produces a steep gradient on the regression line will be more likely to respond positively to educational input than one with a shallow gradient; it could be argued that education about global warming might be best targeted at those actions with a steep slope. A graph illustrating a generic example of this procedure is

shown in Figure 1. From Figure 1 it can be seen that this method produces two other indices; we have designated these the *Natural Willingness to Act* and the *Natural Reluctance to Act*. The former represents the extent to which students will undertake an action even when they believe that it is not at all effective in reducing global warming; the latter indicates the extent to which they will not undertake an action even if they believe it is highly effective. Calculation of these indices indicates the potential roles in different countries for education about the importance, for reducing GW, of public transport instead of private cars, or the use of smaller cars with fewer emissions.

Table 2 shows the values for the *Potential Effectiveness in Education* for students in different countries for using smaller, more fuel-efficient cars. Some countries, like Spain and Singapore have relatively high values for the *Potential Effectiveness in Education* (that is, the slope of the regression line is comparatively steep) and correspondingly low values for the *Natural Reluctance to Act*. In countries such as these, education which persuades students of the environmental benefits, in terms of GW, of smaller private cars may contribute to behavior change. For some other countries the *Potential Effectiveness in Education* is relatively low, but this is because the *Natural Willingness to Act* is comparatively high; Brunei and Turkey are in this group. In these countries people are willing to use smaller cars independent of their belief about the environmental benefits. A third group of countries also shows a low *Potential Effectiveness in Education*, but in this case this is because the *Natural Reluctance to Act* is high. Students in Greece, for example, show this type of response. In such countries it is unlikely that education, even if it should persuade students of the environmental benefits of using smaller cars, will have a strong effect on behavior.

A similar situation obtains for the willingness to use public rather than private transport. Students from some countries, like Spain and Singapore, show relatively high values for the *Potential Effectiveness in Education* for this action (Table 3). In these countries, then, education about the effectiveness of this action might have an important influence in the intention people have to use public transport. In the case of the USA, the *Potential Effectiveness in Education* is not especially low, but students here have a very low *Natural Willingness to Act*. So, even though resistance to using public transport is high in the USA, there might be some positive influence of persuading students about its effectiveness in reducing global warming. Finally, there are some countries in which the *Potential Effectiveness in Education* is low because there is a high *Natural Reluctance to Act*; Australia and the UK are such countries.

Conclusions and Discussion

The present international study explores students' attitudes towards pro-environmental actions to reduce global warming, in particular actions concerned with personal transport. We have attempted to quantify the relationship between belief in the extent of the usefulness of certain actions and the degree of willingness to undertake them. By so doing, we have been able to compare the responses of students from 11 different countries about their belief, readiness to act and the relationship between these variables.

Across almost all of the countries there was less support for the use of public transport than for using a more efficient car. This is congruent with the findings of Black, Stern and Elsework (1985) that curtailment actions (such as ceasing to use private transport) are more difficult to adopt than ones that improve efficiency (such as using a smaller car). However,

adoption of efficiency-improvement actions is dependent on purchasing power; a person with low acquisition capacity will have not the option to invest money in an efficiency-improvement action.

Students from all countries believed that both the use of small cars and the use of public transport can contribute to a reduction in GW. Despite this relatively consistent level of belief, respondents from some countries expressed a greater intention to change their behavior than respondents from the other countries. So, the association between the belief in the usefulness of these actions and the intention to undertake that action in the future is stronger for some countries than for others. We have quantified this association by constructing indices to indicate the *Potential Effectiveness of Education*, the *Natural Willingness to Act* and the *Natural Reluctance to Act*. These analyses showed that students in different countries are likely to react to different degrees, in terms of behavior modification, to education about the effectiveness in reducing global warming of using smaller cars and public transport. Such findings enable environmental education to be better targeted. For example, whereas students in the USA, Spain and Singapore may respond to this kind of education by changing their readiness to take these pro-environmental actions, students Brunei and Greece may be more refractory to this kind of education. In these countries, other forms of influence will be required to elicit adoption of these actions. Students in some countries like the UK or Australia proved to be moderately non-reactive to education because they had a high *Natural Reluctance to Act*, that is the rejection people have for this action is so great that it blocks the behavioral change. In such countries, it is important to discover the reasons for this *Natural Reluctance to Act*, since these reasons will act as barriers to adopting new environmentally-sympathetic behaviors. These barriers, highlighted by Kollmus and Ageyman (2002), may well be related to physical inhibitors and facilitators (Corraliza and Berenguer, 2000), the social norms (Cialdini, Reno and Kallgren, 1990) or motives for community involvement (Batson, Ahmad and Tsang, 2002), amongst others.

In conclusion, in our findings show that the efficacy of environmental education in effecting behavior change will vary according to the specific actions involved and in relation to the socio-cultural background. Elucidation of these variables is an important step in identifying the factors that underlie the gap between belief about the usefulness of actions and pro-environmental action itself. In this way, it can inform the design of strategies that may help to bridge this gap.

Table 1: Wording of the Permissible Responses to the Two Sets of Items

Believed Usefulness of Action **If I thought an Action Would Help Global Warming by**	**Score**	*Degree of Willingness to Act* **Then I would…**	**Score**
by quite a lot	1. 00	definitely do it	1. 00
by a fair amount	0. 75	almost certainly do it	0. 75
by a small but useful amount	0. 50	probably do it	0. 50
by a very small amount - hardly noticeable	0. 25	perhaps do it	0. 25
by nothing at all really	0. 00	probably not do it	0. 00

The wording of the permissible responses are displayed 'matched'. This 'matching' suggests the minimum action ('then I would') that might reasonably be expected for a given belief about the usefulness of that action. The figures show the scores assigned to the different responses; these enabled various coefficients to be constructed.

Table 2: Students' *Natural Willingness to Act*, *Potential Effectiveness in Education and Natural Reluctance to Act* for using Smaller, more Fuel-efficient Cars

	Natural Willingness to Act	*Potential Effectiveness in Education*	*Natural Reluctance to Act*
Australia	0.44	0.14	0.43
Brunei	0.59	0.12	0.29
Greece	0.43	0.11	0.47
India	0.60	0.19	0.21
Korea	0.35	0.18	0.46
Oman	0.55	0.05	0.40
Singapore	0.51	0.20	0.29
Spain	0.45	0.25	0.30
Turkey	0.59	0.12	0.29
UK	0.29	0.17	0.54
USA	0.35	0.28	0.37

Table 3: Students' *Natural Willingness to Act*, *Potential Effectiveness in Education and Natural Reluctance to Act* for using Public Rather than Private Transport

	Natural Willingness to Act	*Potential Effectiveness in Education*	*Natural Reluctance to Act*
Australia	0.24	0.12	0.63
Brunei	0.42	0.04	0.54
Greece	0.38	0.13	0.49
India	0.51	0.15	0.34
Korea	0.34	0.20	0.45
Oman	0.30	0.16	0.54

Singapore	0.38	0.31	0.31
Spain	0.30	0.31	0.39
Turkey	0.32	0.21	0.47
UK	0.19	0.18	0.63
USA	0.17	0.21	0.63

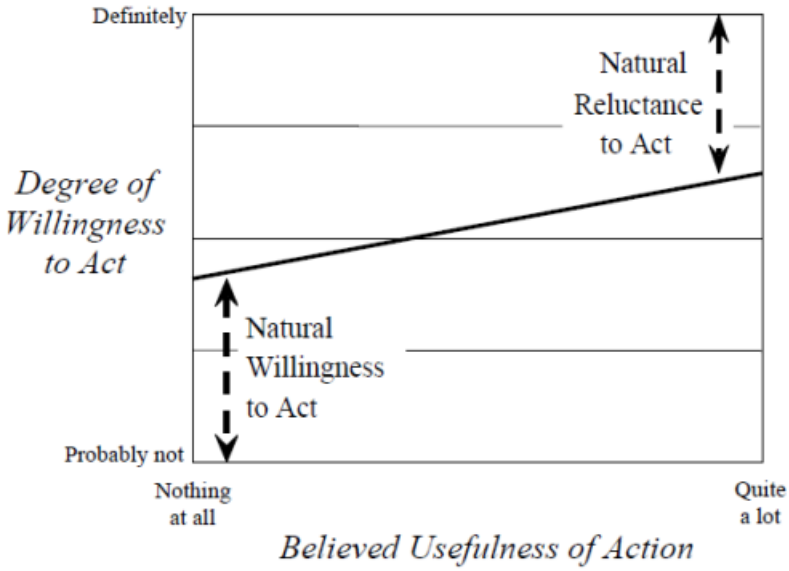

Figure 1: Annotated Graph to Show the Nature of the
Potential Effectiveness of Education, *Natural Willingness to Act and Natural Reluctance to Act*

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About the Authors

Dr. Manuel Rodríguez

In 2004 I began my PhD studying how pupils of different ages conceptualise Sustainable Development, that is to say, how they understand pollution, shortage of resources, electricity production and consumption and wasted managed. One of the aims of the research was to analyse how they established relationship between the knowledge that belong to two different domains: the social-economic and the chemist-physical. In 2006 I carried out a research stay in Liverpool in order to collaborate with Doctors Stanisstreet and Boyes. We began a passionate detour on scientific education. Now we are concluding a cross-country project where we are interested in define some elements that can help us to circumvent the 'gap' between knowledge instruction and pro-environmental actions.

Dr. Eddie Boyes

Dr. Eddie Boyes has taught at most levels in science education, including the training of Physics teachers. On Masters programmes, he has taught options on Assessment, Misconceptions in Science, and Statistics in Educational Research. He publishes widely in the Educational research journals. He has been involved in the data acquisition and analysis of

a number of national research projects, including an early evaluation of the implementation of the UK National Curriculum. More recent work has been concerned with analysing the performance of items which were trialled for National Curriculum Science Assessment in England and Wales.

Dr. Martin Stanisstreet
Dr. Martin Stanisstreet has a BSc (Hons) (1968) in Zoology from the University of Southampton and a PhD (1972) in Developmental Biology from the University of Bristol. He is now a senior lecturer at the University of Liverpool. Dr Stanisstreet has considerable teaching experience at the undergraduate level, including supervision of Level 3 undergraduate research projects, and he has supervised postgraduate students. For the first part of his professional research career he undertook biological research, but he then developed an interest in education research, partly through a series of collaborations with Dr Eddie Boyes. Dr Stanisstreet's current research interests include public preconceptions and misconceptions about major environmental issues, and students' attitudes to school science. Some time ago Dr Boyes and Dr Stanisstreet founded the University of Liverpool Environmental Education Research Unit.

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