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Examining perspectives for education regarding international concerns in science and society

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Abstract

The study documents the views and attitudes of French students, aged 14 or 15 years, about science and technology in society and are compared with a number of other studies and with the wider international context as revealed by other ROSE studies. Although the research reveals a number of gender differences in the French students' responses, it is clear that these mirror those of students from other developed countries and contrast markedly with those of students from the developing world. The students' opinions are also placed in the wider context of adult French citizens views about science, technology and society. It is suggested that many students appear to have a dichotomous view of science: a common view that they share with the society in which they live and western culture (here the students align with the adults) and a more personal view that reflects their individual lives, needs and desires (here they differ from adults and from other young people in developing countries). While the common view seems rooted on social values, the personal perspective is more linked to issues such as self-identity.

Keywords: French students, science and society, science education, scientific literacy, Rose questionnaire

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I. INTRODUCTION

One of the notable features of the past half of a century is the publication of a steady stream of reports, inquiries and commentaries into the state of school science education. Some have been issued or commissioned by governments and other organizations at national and international level (e.g., AAAS, 1989, 1993; European Commission, 2004, 2009; House of Lords, 2006; National Research Council, 1996, 2013;) or initiated by individual science educators (e.g., Hurd 1986, 2002; Millar & Osborne, 1998). Most have been prompted by issues of national concern (e.g., Dercourt, 2004; Kalali, 2010; Rolland, 2006; Thélot, 2004).

Many of the publications have sought to redefine school science education in ways that acknowledge the role that science and technology have come to play, in a world in which globalizing influences tend to promote the homogenization of science curricula, and which are underpinned by notions of equity and accessibility (Carter, 2005). In contrast, how young people perceive the role and the function of science and technology in society has received rather less attention from researchers. In addition, it has been argued that most accounts of scientific literacy have generally paid insufficient regard to the complexities of the increasingly globalized and techno-scientific world (DeBoer, 2000; Hurd, 2002; Millar & Osborne, 1998). For Carter (2005), the trend towards the homogenization of school science curricula reflects both the expansion of western culture and the growth of supranational regulation. The study aims to highlight how young people conceive science in society. The aim is to draw consequences for the school science education.

II. SCIENCE AND PUBLIC: A NEED OF INTERNATIONAL STUDIES

Science is placed within a contradiction. While science means some progress, at the public level the quality of life and the environment cannot be sacrificed to the material benefits of industrialization. To resolve this contradiction, international surveys on citizens' attitudes emerge as a need to provide explanations. However, these international surveys have been teen to institutional and political decision-making. This modernization effort leads to new forms of regular social and political internationalization and globalization (Pestre, 2003), that encourage new forms of participative democracy (Callon et al., 2001). Various emblematic reports have indeed aimed at modernizing research and have legitimized these studies (e.g., Bodmer, 1985; House of Lords, 2000; European Union, 2006). The concern is the fluctuation of public's attitudes towards science, which oscillate between adulation and hostility, before to stabilize as an ambivalence. The goal for the Royal Society is to improve the communication of scientists to the public, because it fears a decrease in research findings.

S. Miller (2001) outlines the institutional and political context of the production of the first two reports. The Bodmer report "*Public Understanding of Science*" (1985) produced by the Royal Society aims to develop a positive image of science and technology. It's in fact used to promote acceptance and public recognition of techno scientific developments, as well as to train scientifically literate citizens. But, the approach adopted remains faithful to the deficit model promoted in the USA through the surveys of J.D. Miller, director of the ICASL, coupled with a deficit of attitudes.[1] The second report of the House of Lords "*Science and Society*" (2000) inaugurates a new SL as the Public Understanding of Science (PUS). This report adopts John Durant's new definition of "understanding how science really works" through societal aspects and through the production of new knowledge and validation. It revokes the definition of science based on facts and methods, disseminated by J.D. Miller, which has served as a conceptual framework for various investigations since the 1970s, and by Durant at the beginning of PUS. The latest European Union's report "From Science and Society to *Science in Society*" (2006) achieves the new communication around science by involving citizens.

III. STUDIES IN FRENCH CONTEXT

The survey conducted by Postel-Vinay in 2002 involving 549 young French people aged between 15 and 25 years was conducted by e-mail rather than a paper-based questionnaire. 50% of the 15-25 year old (male and female) considered that scientific advances presented serious threats to the environment and 46% agreed that the many benefits of science were equaled by the associated harm. the survey revealed significant gender differences in the responses. Females were more convinced than boys of the power of science to create a vaccine against AIDS (80% compared with 50%) and they were more ready to agree that the progress of science presented serious threats to the environment (76% compared with 55%).

The distrust of/ambivalence about science displayed by students at fifteen years and by 15-25 years old contrast with the positive attitude and confidence toward science shared with the results of the survey undertaken by the magazine *La Recherche* and the newspaper *Le Monde* (IPSOS, 2011). Again findings need to be treated with caution, especially since the sampling procedures and design are again different. In this 2011 study (n = 1003), 75% of adult people regarded scientific knowledge as 'the solution to the problems we face today' and no less than 93% considered that it was 'important to know the research problems we face today'. Confidence in scientists reached 69% in relation to new sources of energy and technology, but this fell to 35% and 33% respectively in the case of nuclear energy and genetically modified organisms. When the survey was repeated in 2013 (IPSOS, 2013),

[1]The results confirm the scientists' point of view : only 10% of respondents are considered scientifically literate, which shows a level that can be held as low, and similar to USA.

there was small changes in the pattern of responses, the proportion agreeing that 'scientific knowledge is the solution to the problems we face today' rising to 78% (n = 1004). The overall picture from these two surveys is that the French public's assessment of scientific and technological development is broadly positive for society and about those aspects of daily life (Witowski & Boy, 2001).

The national picture in France is complemented by a more local study undertaken in 2009 in the Department of the Val-de-Marne (in Créteil) by the Association for Science and Technology (ASTS). Using a representative sample of 1,000 people of the population aged 18 and over, interviews were conducted via a self-administered online questionnaire (CAWI - Computer Assisted Web Interviewing). The sample population claimed a high level of interest in science but also showed limited scientific knowledge (IFOP, 2009). The principal sources of scientific information were identified as the Internet (80%) and television (74%). Science was considered essential for the citizen in order to understand a variety of societal issues whether or not they were linked directly to science. Discussions focusing on the applications of science were of interest to 81% of the sample while 65% said they were interested in the debates about the teaching of science at school. There were marked gender differences within the population: men, graduates and senior citizens showed a stronger interest in science than most of the other categories surveyed. Many of the gender differences paralleled those found in the studies reported above, with females being more skeptical than males about the actual and potential benefits of science and technology.

IV. INTERNATIONAL STUDIES

The trend towards participation of citizen, and preparing young people -as future citizen to meet the challenges that they will face as adults in their lives- has been encouraged by the growing importance attached by governments to the outcomes of international comparative studies, notably the Trends in International Mathematics and Science Study (TIMSS) and the OECD Programme for International Student Assessment (PISA). Although TIMSS and PISA are directed towards the common goal of raising students' performance and interest in science, they differ in important ways. Whereas TIMSS has directed its attention in assessment instruments at the scientific and mathematical knowledge acquired at school, PISA offers an operational definition of scientific literacy that takes no account of national differences and seeks to measure how well school science has equipped students to function as scientifically literate adults in the world in which they will live and work.

Unsurprisingly, both the notion of scientific literacy (Shamos, 1995) and the assumptions underlying PISA, notably the neglect of the economic, social and cultural contexts of scientific knowledge, have been criticized (Sjøberg, 2012). In addition to a number of country-specific studies reviewed by Jenkins (2006), the most important international comparative study to date of students' attitudes towards/opinions about science and school science is the ROSE project. This is a development of an earlier Science and Scientists project (SAS) (Sjøberg, 2000) which was based on the belief that science education should primarily prepare young people to meet the challenges they will face as adults (Schreiner & Sjøberg, 2004).

By focusing on attitudinal factors and on cultural differences directly rather than indirectly via other factors such as school ranking, subjects or students' choice of courses, the ROSE project has provided information that complements the standards, benchmarks and indicators that are the results of other studies (Schreiner & Sjøberg, 2004). The current study of French students' attitudes towards/views about science and technology in society forms part of a much wider international survey, the Relevance of Science Education (ROSE) project, based at the University of Oslo and directed by Professor Svein Sjøberg. Details of the questionnaire (Schreiner & Sjøberg, 2004) and information about the countries involved can be found in Sjøberg and Schreiner (2010) or on the project web site (roseproject.no). These sources examine a range of technical and methodological issues, including the rationale, design, piloting and deployment of the ROSE questionnaire, reliability, validity and credibility, and the limitations of a Likert-type scale. The reader is referred to these resources for the necessary details.

Many science educators have expressed views about how school science education should be improved although they inevitably choose to stress different goals, such as education for citizenship, for democracy or for socio-political action. Reviews have drawn upon PISA and TIMSS data and some recent work has attempted to relate ROSE data to these benchmark reports (Awan & al., 2011; Eurydice, 2011; Fensham, 2007; Harlen, 2010; ICSU, 2011; Osborne & Dillon, 2008; Veille Sientifique et Technique [VST], 2009). The reviews present a picture of the state of science education in Europe (and much of the rest of the world), highlighting its aims, status, difficulties and challenges. In this picture, scientific literacy emerges as a central aim of science education policy and practice. The corresponding challenge is to devise a science education that accommodates the fundamental scientific and the civic dimensions of science education, a challenge that has become the goal of politicians and science educators in many countries.

This science education is meant an update of knowledge through standards in rather political documents such as those of the AAAS (Collins, 1998). Others views draw attention to the need for the consistency with science as it moves forwards in society. These raise some problems like understanding scientific practices (Martinand, 2006); the focus attention on backing a certain elite (Apple 1992; Osborne and Calabrese-Barton, 2000), the critic of the science literacy/knowledge deficit model (e.g., Evans and Durant, 1995) and finally a need to integrate science into society (Wynne, 1995).

The questions asked in all these studies did not allow the respondents, especially students, to have the opportunity to suggest any reforms they might have thought desirable. While some earlier studies of the "student voice" (Jenkins 2006) have focused on students' interests in, or attitudes towards, science and scientists (e.g., Lehrke and al.,1985; Tamir & Gardner, 1989; Schibeci, 1984), other work has complemented this core of studies by redirecting research at exploring more directly on what students think about their school science education (e.g., Osborne & Collins, 2001) and on the role of science and technology in society and on scientific and technological developments (Eckersley, 1999). Hicks and Holden (1995) explored the relationship between students' attitudes about the role of science in society and their sense of optimism about the future, a relationship that is also of interest to researchers in the field of citizenship education (Hicks & Holden, 2007). For some researchers into students opinions, gender differences and gender stereotyping have been the focus of particular attention (see, for example, Brotman & Moore, 2008; Eckersley, 1999/2002; Hicks, 1996; Reis & Park, 2001) and (Dutrévis & Toczek, 2007; Kalali, 2019; Mariotti, 2002; Palmer, 1997; Schibeci & Lee-Hammond, 2003).

V. METHOD

The research reported here is based on students' responses to the section of the questionnaire entitled "My opinion about science and technology" (Section G of the complete ROSE questionnaire). The section consists of statements that explore students' interest in, and support and possible trust or distrust of, science and scientists.

The ROSE questionnaire was piloted in a number of national and international preliminary studies in countries that necessarily differed historically, culturally, socially, economically and politically. The complete validated ROSE questionnaire[2] invites students to respond using a four-point Likert-type scale to a series of about 250 closed items covering several different aspects of science, technology and science education. The target population is pupils towards the end of secondary school (age 15). The present research addresses the following questions:

- What are French students' attitudes towards science and technology?
- Are there any significant gender differences in the attitudes of the French students?
- How do their attitudes compare with those of students in other countries?

[2]Three of the sections invite students to answer to a series of statements about what they would like to learn. Other sections are "My future job", "Me and the environmental challenges", "My science classes", "My opinion about science and technology", and "My out-of-school experiences". The one open question asks students "What I would do as a scientific researcher".

Many of the questions parallel those used in large scale public survey such as the Eurobarometer (2001) and the Science and Engineering Indicators produced by the National Science Board in the USA.
The latest question is:
How do the views of the French students compare with those of adults in France?

The ROSE questionnaire uses a 4-point Likert-type scale, the limitations of which are given in the ROSE documentation and which are also well-described by Cohen and al. (2000) and Aikenhead and Ryan (1992). The latter have shown that differences in understanding the items on the part of the researcher and the respondents can generate ambiguities which affect the interpretation of the scores. Nevertheless, the Likert-type scale, through the calculation of averages, remains a convenient way of exploring the answers given by the sample of students although it can indicate nothing about the attitude of an individual student (Gardner, 1995). The processing of data allows the researcher to identify some constellations of elements which appear with some frequency. These constellations are, of course, not descriptions of groups or of individual students, but simply theoretical constructions (Weber, 1965).

Sampling

Since 1975, French students aged from 11 to 15 have followed the same syllabus in a single school (collège unique) regardless of any social diversity among the intake. The sample on which this study is based was drawn from students in Year 9 attending schools in Paris and in Créteil in the region Francilienne which constitutes about one tenth of the total number of comparable schools in metropolitan France. Approximately one quarter of the pupils in the two regions were involved in the survey. According to Dercourt (2004), this region can be taken as reasonably representative of metropolitan France as a whole and is unlikely to introduce significant distortions either in the sampling or the subsequent analysis.

The sample of schools was determined in meetings with the relevant inspector and took account of differences in school structure, pupil intake, staffing etc. Sampling thus targeted all the schools that form the 'Academy' of Paris. A total of 1,289 questionnaires were wholly completed from 61 schools with a gender ratio of 713 girls to 576 boys. Identification of the individual schools that participated in the research showed that they were divided evenly between the 20 arrondissements that make up the city of Paris. In Créteil, the schools sampled were distributed so as to reflect the geographical diversity of the Department. Overall, 53 of 60 target schools (about 1,106 students; 551 girls, 555 boys) responded to the ROSE questionnaire. Questionnaires were sent by the responsible authorities to the two parts of the 'Academy' of Paris and Créteil, and the questionnaires were distributed to a class chosen at random by the Director within each school. The students' responses were coded in our laboratory and analysed by the researcher in accordance with the procedure laid down by the ROSE Project in Oslo. Their treatment was made in SPSS as recommended by the Norwegians of the project managers and sent to University of Oslo.

VI. RESULTS

The students' responses to the sixteen statements in the section "My opinion about science and technology" of the ROSE questionnaire are given in Table 1. Gender differences and differences between the responses of students in the two sample areas in these responses, with an indication of their statistical significance (Independent-Sample t-test and Cohen's d measure), are given in Table 2 and 3 respectively.

Descriptive statistics and statistical significance

Item	Strongly Agree	agree	Disagree	Strongly Disagree	Nil Response
	%	%	%	%	%
1. Science and technology are important for society	42	27.5	16.3	12	2.2
2. Science and technology will find cures for such diseases as HIV/AIDS, cancer, etc.	52.6	27.8	11.5	5.6	2.5
3. Thanks to science and technology, there will be greater opportunities for future generations	43.2	29.5	14.4	10.4	2.4
4. Science and technology make our lives healthier, easier and more comfortable	31.8	29.4	21.5	14.4	2.8
5. New technology will make work more interesting	30.2	27.9	22.6	16.3	2.9
6. The benefits of science are greater than the harmful effects it could have	14.9	23.3	31	23.5	7.2
7. Science and technology will help to eradicate poverty and famine in the world	44.8	30.6	13.1	8.1	3.4
8. science and technology can solve nearly all problems	8.6	15.7	28.5	44	3.2
9. Science and technology are helping the poor	6.9	11.9	28.4	49.1	3.7
10. Science and technology are the cause of environmental problems	17.8	24.7	27	25.3	5.3
11. A country needs science and technology to become developed	43.7	30.9	13.7	8.6	3
12. Science and technology benefit mainly the developed countries	43.5	27.2	14.2	11.1	3.9
13. Scientists follow the scientific method that always leads them to correct answers	8.2	17.5	31.4	38.9	4
14. We should always trust what scientists have to say	6.1	11.1	24.8	54.9	3
15. Scientists are neutral and objective	12.9	21.5	30.7	30.1	4.7
16. Scientific theories develop and change all the time	30.7	28.7	21.1	14.4	5.1

Table 1. French students' responses about «My opinion about science and technology»

Item	Girls		Boys		t	p	d
	Mean	S.D.	Mean	S.D.			
1. Science and technology are important for society	2.98	1.050	3.10	1.085	-2.88	.004*	-0.11▪
2. Science and technology will find cures for such diseases as HIV/AIDS, cancer, etc.	3.38	.851	3.26	.970	3.206	.001*	0.13▪
3. Thanks to science and technology, there will be greater opportunities for future generations	3.04	1.030	3.15	1.014	-2.54	.011*	-0.46□
4. Science and technology make our lives healthier, easier and more comfortable	2.73	1.074	2.93	1.058	-4.6	.000*	-0.18▪
5. New technology will make work more interesting	2.66	1.089	2.87	1.099	-4.58	.000*	-0.14▪
6. The benefits of science are greater than the harmful effects it could have	2.25	1.032	2.43	1.091	-3.94	.000*	-0.17▪
7. Science and technology will help to eradicate poverty and famine in the world	2.63	1.159	2.75	1.152	-2.45	.014*	-0.10▪
8. Science and technology can solve nearly all problems	1.78	.935	2.03	1.089	-6.15	.000*	-0.25□
9. Science and technology are helping the poor	1.65	.879	1.89	1.032	-6.02	.000*	-0.13▪
10. Science and technology are the cause of environmental problems	2.32	1.123	2.49	1.157	-3.52	.000*	-0.13▪
11. A country needs science and technology to become developed	3.08	.968	3.21	.977	-3.11	.002*	-0.13▪
12. Science and technology benefit mainly the developed countries	3.01	1.061	3.17	1.029	-3.57	.000*	-0.15▪
13. Scientists follow the scientific method that always leads them to correct answers	1.85	.939	2.08	1.069	-5.44	.000*	-0.23□
14. We should always trust what scientists have to say	1.58	.890	1.80	1.026	-5.45	.000*	-0.23□
15. Scientists are neutral and objective	2.09	1.019	2.32	1.106	-5.25	.000*	-0.22□
16. Scientific theories develop and change all the time	2.75	1.086	2.88	1.071	-2.79	.005*	-0.12▪

Table 2. Means of girls and boys responses about «My opinion about science and technology»

*** p <0.05 significant**

The means of the boys' and girls' distributions have been compared using the Independent-Samples t-test and as an additional check, we tested the power of the difference using Cohen's d (as d=Mg-Mb/S.D. pooled; S.D. pooled = $\sqrt{[S.Dg^{2} + S.Db^{2}}$ /2] (Cohen, 1988). The Independent-Samples t-test procedure compares means for two groups of cases. Cohen's d measures the effect size for the difference between boys and girls: no effect at d <0.2▪; small effect at 0.2≤d<0.5□; moderate effect at 0.5≤d<0.8; and large effect at d ≥0.8

Item	Paris		Créteil		t	p	d
	Mean	S.D.	Mean	S.D.			
1. Science and technology are important for society	3.09	1.098	2.93	1.063	3.69	.000*	0.10▪
2. Science and technology will find cures for such diseases as HIV/AIDS, cancer, etc.	3.31	.977	3.31	.864	0.306	0.76	0.00▪
3. Thanks to science and technology, there will be greater opportunities for future generations	3.12	1.061	3.04	1.001	1.666	0.1	0.07▪
4. Science and technology make our lives healthier, easier and more comfortable	2.86	1.108	2.74	1.051	2.596	.009*	0.08▪
5. New technology will make work more interesting	2.77	1.143	2.75	1.063	0.04	0.97	0.01▪
6. The benefits of science are greater than the harmful effects it could have	2.41	1.113	2.27	1.006	2.765	.006*	0.13▪
7. Science and technology will help to eradicate poverty and famine in the world	2.71	1.188	2.64	1.125	0.896	0.37	0.06▪
8. Science and technology can solve nearly all problems	1.92	1.052	1.89	.980	0.774	0.44	0.02▪
9. Science and technology are helping the poor	1.79	1.013	1.74	.918	1.859	0.06	0.05▪
10. Science and technology are the cause of environmental problems	2.44	1.204	2.37	1.076	1.434	0.15	0.06▪
11. A country needs science and technology to become developed	3.17	.995	3.08	.981	1.804	0.07	0.04▪
12. Science and technology benefit mainly the developed countries	3.11	1.062	3.03	1.047	2.322	.020*	0.07▪
13. Scientists follow the scientific method that always leads them to correct answers	1.96	1.050	1.96	.980	-0.52	.005*	0.00▪
14. We should always trust what scientists have to say	1.70	1.015	1.70	.916	-0.52	0.6	0.00▪
15. Scientists are neutral and objective	2.22	1.107	2.16	1.024	0.827	0.41	0.05▪
16. Scientific theories develop and change all the time	2.79	1.119	2.79	1.049	0.384	0.7	0.00▪

Table 3. Means of students' responses of Paris and Créteil to section G «My opinion about science and technology»

*** p <0.05 significant**

The means of the boys' and girls' distributions have been compared using the Independent-Samples t-test and as an additional check, we tested the power of the difference using Cohen's d (as d=Mg-Mb/S.D. pooled; S.D. pooled = $\sqrt{[S.Dg^{\ 2} + S.Db^{\ 2}}\ /2]$ (Cohen, 1988). The Independent-Samples t-test procedure compares means for two groups of cases. Cohen's d measures the effect size for the difference between Paris and Créteil: no effect at d <0.2▪; small effect at 0.2≤d<0.5□; moderate effect at 0.5≤d<0.8; and large effect at d ≥0.8

The data (Table 1) show that students agree or agree strongly with the statement that "science and technology will find cures for such diseases as HIV/AIDS, cancer, etc." (statement 2). Such agreement is reflected in the responses to statement 1 that "science and technology are important for society" and to statement 3 that "thanks to science and technology, there will be greater opportunities for future generations". These broad levels of agreement are also manifest in the optimism expressed in the responses to statement 7 ("science and technology will help eradicate poverty and famine in the world"). There is also a clear recognition among many of those responding to the questionnaire that there are limits to the extent to which science and technology can solve problems (statement 8). The importance of science to social and economic development is well-illustrated by the students' responses to statements 11 and 12, although the latter also reflect a belief that science and technology are mainly of benefit to the developed world. The mean scores relating to statements 4 and 5 suggest a somewhat lower level of agreement with the view that "Science and technology are seen as making our lives healthier, easier and more comfortable" and "New technology will make work more interesting".

Those concerned with the wellbeing of science can draw little comfort from the fact that 31% and 23.5% of students disagree and disagree strongly respectively with the assertion that the benefits of science are greater than its potentially harmful effects (statement 6). However, when asked whether what scientists say should always be trusted (statement 14), only 6.1% (strongly agree) and 11.1% (agree) of students answered positively compared with 54.9% who do not agree. This caution is reflected in the responses to statements 13 and 15 relating to scientific methodology and objectivity respectively. Rather discouragingly, relatively few students support the claim that science and technology are helping the poor (statement 9).The distribution of responses to statement 10 indicates a substantial spread of opinion among the students about whether science and technology are the cause of environmental problems.

Table 2 shows that while students' views about science and technology are broadly positive, girls appear to be slightly more confident than boys about the potential of science to cure disease (statement 2). In contrast, boys are slightly more confident than girls about statement 1 (science and technology are important for society), statement 3 (thanks to science and technology, there will be greater opportunities for future generations), statement 11 (a country needs science and technology to become developed) and statement 12 (science and technology benefit mainly the developed countries). All these differences are statistically significant ($p < 0.05$). Girls are more skeptical than boys that science and technology can solve nearly all problems (statements 8), that science and technology are helping the poor (9), that scientists follow the scientific method that always leads them to correct answers (13) and that we should always trust what scientists have to say (14). Differences are statistically significant ($p < 0.05$). Boys are also more confident that girls that science and technology will help to eradicate poverty and famine in the world (statement 7).

Table 3 shows that the students in the two academies express broadly similar degrees of confidence in, and optimism about, science (statements 1, 2, 3, 4, 5, 7). They also display the same degree of skepticism toward scientists and their methods of work (statements 13 and 14). Together with statement 8 (Science and technology can solve nearly all problems) and statement 9 (Science and technology are helping the poor), these statements have the lowest scores and collectively they reflect a strong rejection of the opinions stated in the questionnaire. In a few cases, the scores of the students in Paris show a statistically significant difference from those of the remainder of the overall sample of students. (statements 1, 4, 6, and 12 with $p<0.05$). Trends among Paris and Créteil are not affected by the effect size. It is a real unique message from the two regions about the social and economic benefits of science and mistrust of scientists and their methods. Thus, we can say that students in the two regions expressed the same voice.

Principal factor analysis

Table 4 shows the results of a Principal of Component Analysis of the responses for girls and boys respectively. In order to ensure that such an analysis could be applied appropriately to the responses to Section G of the ROSE questionnaire, it was first established that none of the items had a correlation coefficient less than 0.20. Principal of Component Analysis was shown to be relevant to the analysis following testing using the Kaiser-Mayer-Olkin and Bartlett sphericity procedures.

Item	Component 1	Component 2
1. Science and technology are important for society	**(.807)** .200	(.187) **.729**
2. Science and technology will find cures for such diseases as HIV/AIDS, cancer, etc.	**(.796)** .215	(.204) **.716**
3. Thanks to science and technology, there will be greater opportunities for future generations	**(.809)** .127	(.237) **.813**
4. Science and technology make our lives healthier, easier and more comfortable	**(.711)** .300	(.353) **.681**
5. New technology will make work more interesting	**(.610)** .323	(.381) **.642**
6. The benefits of science are greater than the harmful effects it could have	**(.518) .436**	**(.436)** .345
7. Science and technology will help to eradicate poverty and famine in the world	**(.536) .512**	**(.506) .400**
8. Science and technology can solve nearly all problems	(.288) **.629**	**(.724)** .363
9. Science and technology are helping the poor	(.255) **.663**	**(.776)** .275
10. Science and technology are the cause of environmental problems	(.286) **.570**	**(.600)** .193
11. A country needs science and technology to become developed	**(.631) .473**	**(.460) .484**
12. Science and technology benefit mainly developed countries	**(.605) .516**	**(.461) .441**
13. Scientists follow scientific methods that always lead them to correct answers	(.248) **.700**	**(.704)** .147
14. We should always trust what scientists have to say	(.209) **.742**	**(.815)** .210
15. Scientists are neutral and objective	(.329) **.742**	**(.678)** .146
16. Scientific theories develop and change all the time	**(.442) .624**	**(.518)** .210

Table 4. Principal Component Analysis of «My opinion about science and technology» for girls and (boys)

Extraction Method/ principal component Analysis. Rotation Method: Varimax with Kaiser Normalization. A rotation converged in 3 iterations.

The Analysis identified two main factors for girls and for boys: the percentage of variance in the case of girls is 41.82% and 8.45% and the corresponding percentages of boys are 50.88% and 8.0%. Positive views about the role and benefit of science and technology are evident for boys in component 1. The same views are evident for girls in component 2 (8.0% of variance) with differences in the responses to items G6 and G16. Although both boys (component 1) and girls (component 2) express optimism about science, ("science and technology are important for society", "science and technology will find cures for such diseases as HIV/AIDS, cancer, etc.", "thanks to science and technology, there will be greater opportunities for future generations", "science and technology make our lives healthier, easier and more comfortable"), this does not correlate with the confidence they express in scientists and their methods of work (statements 13, 14, 15). Unlike boys, these girls do not believe that the benefits of science are greater than their harmful effects whatever their optimism towards science.

The results show that, in the case of girls, those who have confidence in scientists and their methods (component 1) also subscribe to the view that "science and technology will help to eradicate poverty and famine in the world", that "science and technology can solve nearly all problems", that "scientific theories develop and change all the time" and that "science and technology are helping the poor" (statements 7, 8, 9). Boys (component 2) also who expressed confidence in scientists and in their methods ("scientists are neutral and objective", "we should always trust what scientists have to say", scientists follow scientific methods that always lead them to correct answers", and "scientific theories develop and change all the time") also hold that science is able to solve all problems including poverty and hunger (statements 7, 8 and 9). Both boys and girls subscribe to the opinion that "the science and technology are the cause of environmental problems" but do not express positive attitudes towards science ("science and technology are important for society", "science and technology will find cures for such diseases as HIV/AIDS, cancer, etc."). Boys and girls believe that science is mainly of benefit to developed countries (statement 12).

International trends

Data from the ROSE project in different countries enable the data reported above to be placed in the wider international context. The histograms in the Appendix illustrate how some of the results of French students compare with those of students from 35 other countries, using a sample of items from Section G of the ROSE questionnaire. Young people in most countries show similar responses to statements 1 & 11 ("science and technology are important for society" and "a country needs science and technology to become developed"), although there are lower levels of agreement in the case of Scotland (mean 2.73; S.D. 0.993), North Ireland (mean 2.88; S.D. 1.089), England (mean 2.99; S.D. 0.982) and Spain (mean 2. 92; S.D. 0.683). The mean score in the case of Statement G6 (The benefits of science are greater than its potential harmful effects), is greater than 3.0 for a number of developing countries: Uganda (mean 3.13; S.D. 1.223), Ghana: (mean 3.0; S.D. 1.006), Lesotho (mean 3.04; S.D. 1.099), Philippines (mean 3.02; S.D. 0.934), Bangladesh (mean 3.43; S.D. 0.935) and Malaysia (mean 3.03; S.D. 0.908). In France, as in other developed and industrialized countries, the responses to this item score below 3.0, and France joins Japan in recording the two lowest scores (Japan, mean 2.11; S.D. 0.859), France (mean 2.33; S.D. 1.064).

However, while students in developing countries express a substantial degree of confidence in "the ability of science to address the problems of poverty" (statement 9), the responses of students in the developed world seem to be less uniform. For several countries including Spain, France, Austria, Greece and Germany, the mean scores in response to this item are below 2.0. In other countries, including Norway, Japan, England, Poland and Scotland, the mean scores are greater than 2.0. The results from the French students, mean scores 1.65 (girls) and 1.89 (boys), suggest that the country belongs in the former group. Interestingly, French students appear to be more confident than their peers in a number of other developed nations in their belief that science and technology benefit mainly the developed countries (statement 12), In contrast, France also belongs with those countries (the majority) in which most students do not agree with the assertion that what scientists say should always be trusted (statement 14). Overall, however, it is clear that the French results are not significantly out of line with those of other developed countries, the majority of which serve to highlight a different pattern of responses from those given by students in the developing world.

VII. DISCUSSION

From the statements presented here about scientists, science and society, we remind that we seek to understand the attitudes of young students in comparison with those of their peers in other countries and those of adults.

How do the responses of the French students compare with those of French adults as revealed by others surveys, including those referred to earlier in this papers?

The degree of distrust of/ambivalence about science displayed by the French ROSE students is mirrored in the earlier survey conducted by Postel-Vinay in 2002. Caution is clearly necessary in comparing results generated by different methodologies and at different times. Despite this, As with the survey of Postel-Vinay (2002), the ROSE sample, revealed significant gender differences in the responses. Although girls are more realistic than boys about "science and technology can solve nearly all problems".

Although young people are rather positive to science and technology, there are signs of a generation shift, where young people, more than the adults, also see the more problematic sides of science and technology (Sjøberg & Schreiner, 2010). Students in most developing countries but few developed world see more benefits than harmful effects in science; in Japan and France the skepticism towards science is considerable (see appendix). ROSE shows that the greatest skepticism is one that affects belief in scientists particularly in the developed countries. This result from developed countries is similar to statement "the ability of science to address the problems of poverty" (statement 9), but it seems to be less uniform (see appendix). It is clear that the French ROSE results are not significantly out of line with those of other developed countries.

The findings reported here are also consistent with the findings from the Eurobarometer within the wider European context. The European Commission, through its Directorate-General (Research), has carried out several surveys since 1992 designed to establish the views of the European public about science and technology. The 2005 survey involved 25 Member States, the then candidate countries of Bulgaria, Romania, Croatia and Turkey and three EFTA countries (Iceland, Norway and Switzerland). Data were obtained from face-to-face interviews conducted in people's homes in the appropriate national language (European Commission, 2005). Most Europeans (88%) were optimistic that scientific and technological progress would help to cure illnesses such as AIDS and cancer and 78% reported that science and technology would make life healthier, easier and more comfortable. The Eurobarometer survey conducted three years later involved almost 25,000 people aged between 15 and 25 from across the 27 Member States of the European Union. Interviews were conducted using land-line telephones (European Commission, 2008). The survey revealed a degree of optimism about science and technology similar to that revealed by the French studies reported here (four point Likert-type scale form strong agreement to strong disagreement, nil response not offered). Although young European citizens (about half of the respondents) strongly agreed that science is essential for future prosperity, only 4 of every 10 males (3 of 10 females) strongly agreed that science makes lives healthier, easier and more comfortable. This change in three years was reflected in a number of other questions in the Eurobarometer survey and according to Sjøberg and Schreiner (2010) required attention by educators and policy makers.

These various national and international studies from young people, young adult and adult provide a picture of the attitudes of youth towards science and technology. It is as if students have a dichotomous view of science: a common view that they share with the society in which they function (here the students align with the adults) and a more personal, individual view that they share with their peers and which reflects their personal needs and aspirations (here they differ from adults and from other young people in developing countries). Young people and adults share a common interest in such issues as caring for others, social justice, equity and progress that help to bind a society together. This common view seems rooted on social values, those are revealed by the Eurobarometer survey "Social values, science and technology" (Gaskell, 2005). The personal perspective is more "problematic" and it is linked to issues such as self-identity and tensions between present and future roles; between individual and collective (which is evoked further). Osborne and Collins (2001) had mentioned, more for boys than girls, the difficulty in elaborating reasons for importance of science to themselves or their own everyday lives. For the former, this would suggest that they held similar sentiments but simply failed to articulate them to the same extent (Osborne & Collins, 2001, p. 448). We must also add that current experience of school science education provides most insight compared to current experience of science in everyday life. The findings reported here from ROSE study show the salience of gender differences with much optimism for boys and much skepticism for girls; exception about to cure disease that has particular connotations for girls. Our findings are in line of those of Eckersley (1999/2002) and Hicks (1996) about increasing pessimism with increasing age and that girls in general hold more pessimistic future images than boys. The understanding of what young people hold on the future is of interest to science and environmental educators; and researches focusing on environmental education are required to provide their contribution to science education.

Although some caveats are required, what are the implications of these findings for research in school science education? Quantitative researches have been often criticized as they reduce the multifaceted and interdependent construct. Indeed, questionnaire-instrument reveals the top of the iceberg without underlying complexity of feeling or view. Moreover, it is necessary to compare the results with research that focus on more qualitative analysis. Rose provides the declarative material from students. In the responses of students we seek to identify some constellations of elements linked together and which appear with some frequency. We avoided use any typology of students because our constellations are not seen as descriptions of real groups or of individual students. We examine what students think and we must be vigilant when we hope to clarify why they think that. In our study, we had tried, from the findings, to examine a range of attitude that are commonly held within population and the strength of those other aspects of attitude. Despite these caveats, the findings presented above can be highlight with the current reform in France (Ministry of National Education in France, 2005). Build a consistent representation of the world by answering scientific and civic questions that are connected shows the choices and priorities that have been fostered in France. The picture of science education evident in the many reports, inquiries and commentaries by governments, organizations presented above contribute to elucidate the meaning of these choices fostered in France. It is for the country make science education to respond to the challenges of the 21st: development of science and technology, globalization of human history. Consequently, the political issue of "multi-faceted" student (Ministry of National Education in France, 2005) refers to someone who built an individual and socialized "theory of world". Someone who is between present and future roles and who use prediction mechanisms / anticipation for meaningful relationships with the real world. This constitution of the cognitive and emotional experience of learning emphasizes also the role of language; this tension between individual and collective. Therefore, this experience is seen as discursive practice. Learners' identities, emotion, beliefs, thoughts, values and judgments must be understood as properties of conversations and performances (ROSE, 1998); matters that are well beyond of the scope of this article.

The dichotomy resonates with current attempts to reform school science education in France based upon the concept of the multi-faceted student referred to earlier. For such education, we join the proposals made by Feinstein, Allen and Jenkins (2013) that points a few reasonable challenges but decisive. The point is to promote personal relevance and integrate scientific knowledge into complex practical solutions without make obsolete the development of students understanding of the social and institutional basis of scientific credibility; and as revealed by studies such as ROSE enable students to build on their own enduring, science-related interests.

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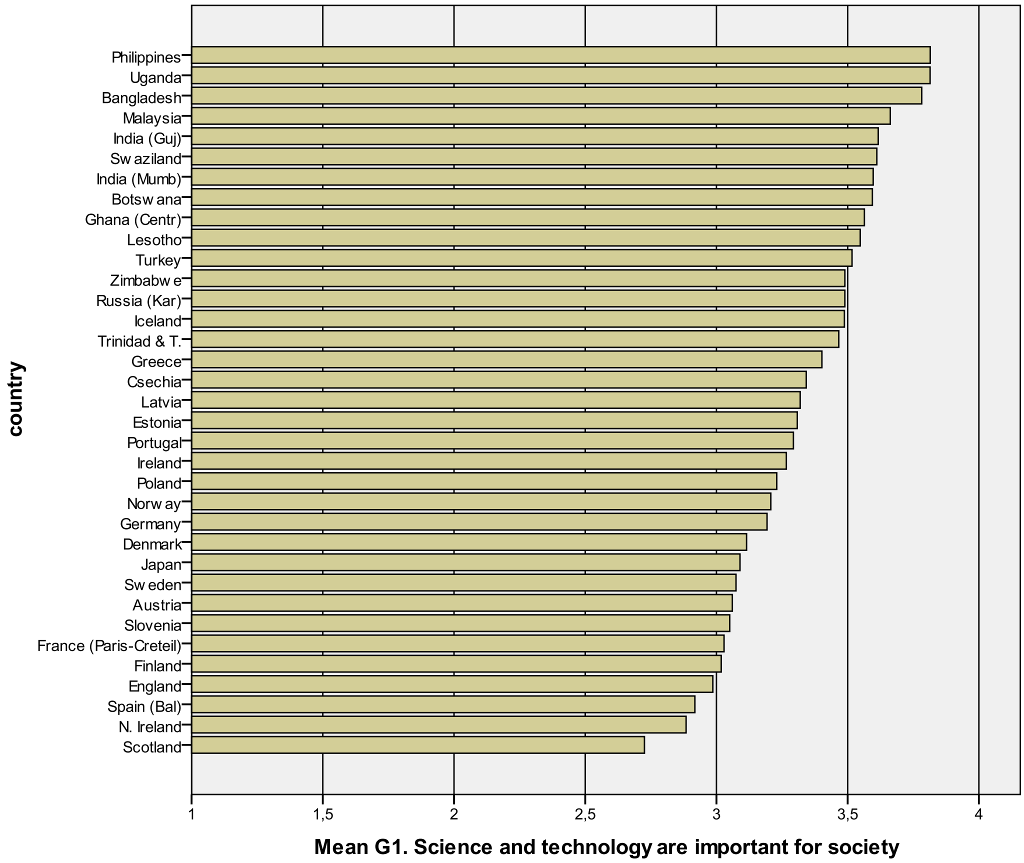
Appendix



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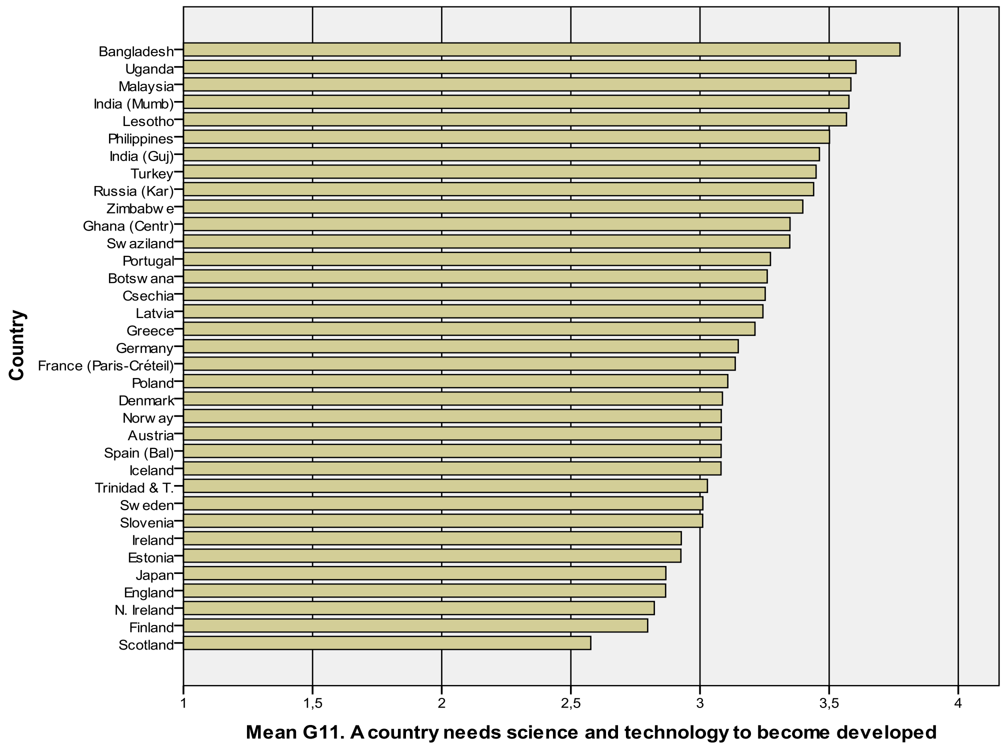
Mean G1. Science and technology are important for society



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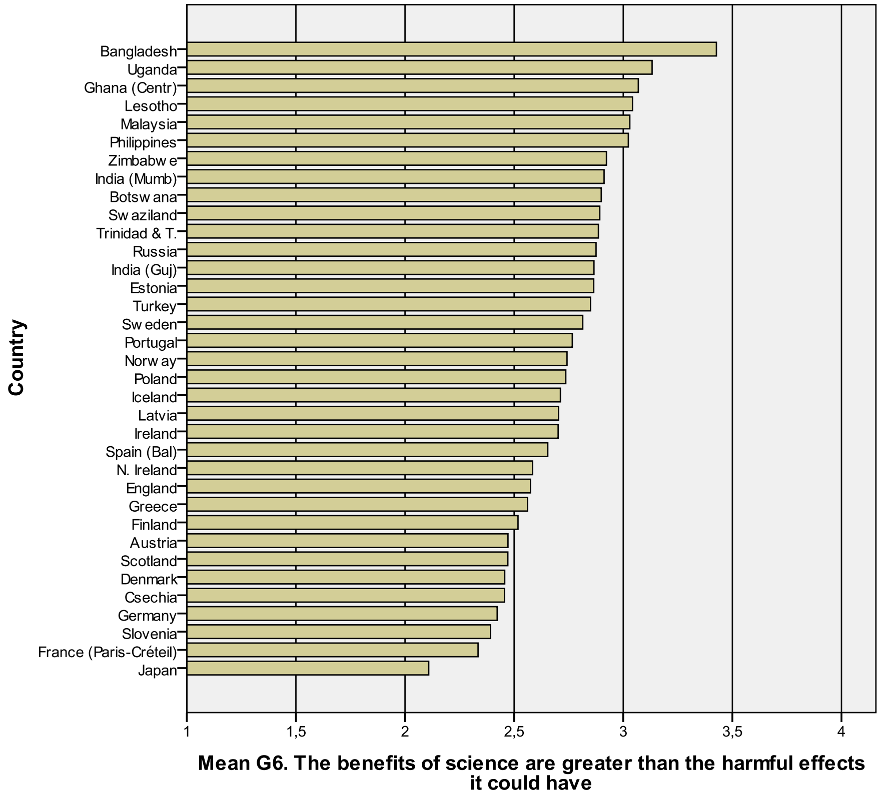
Mean G11. A country needs science and technology to become developed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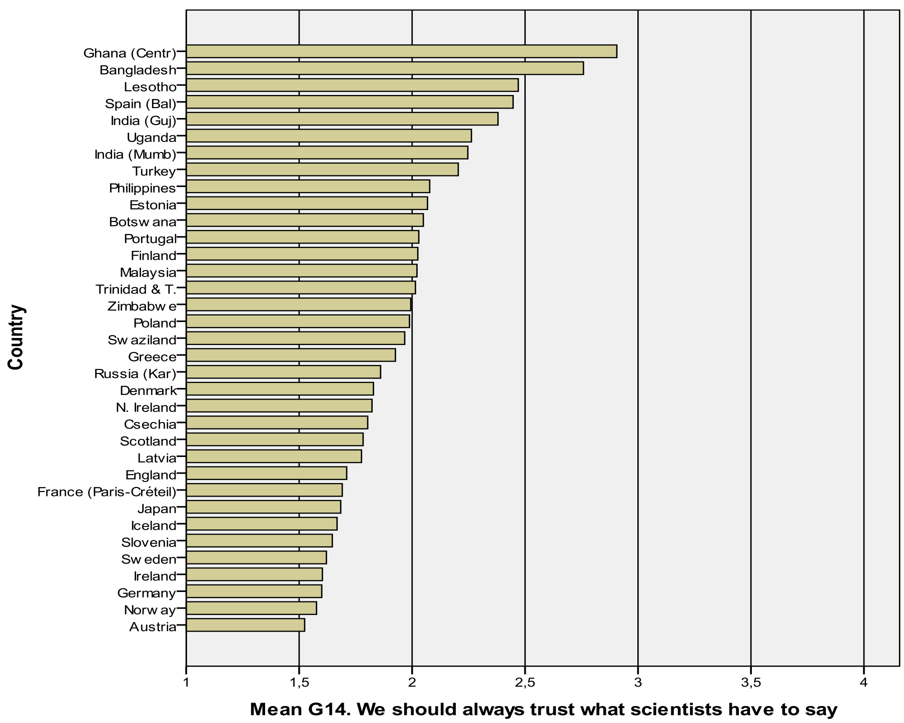
Mean G6. The benefits of science are greater than the harmful effects it could have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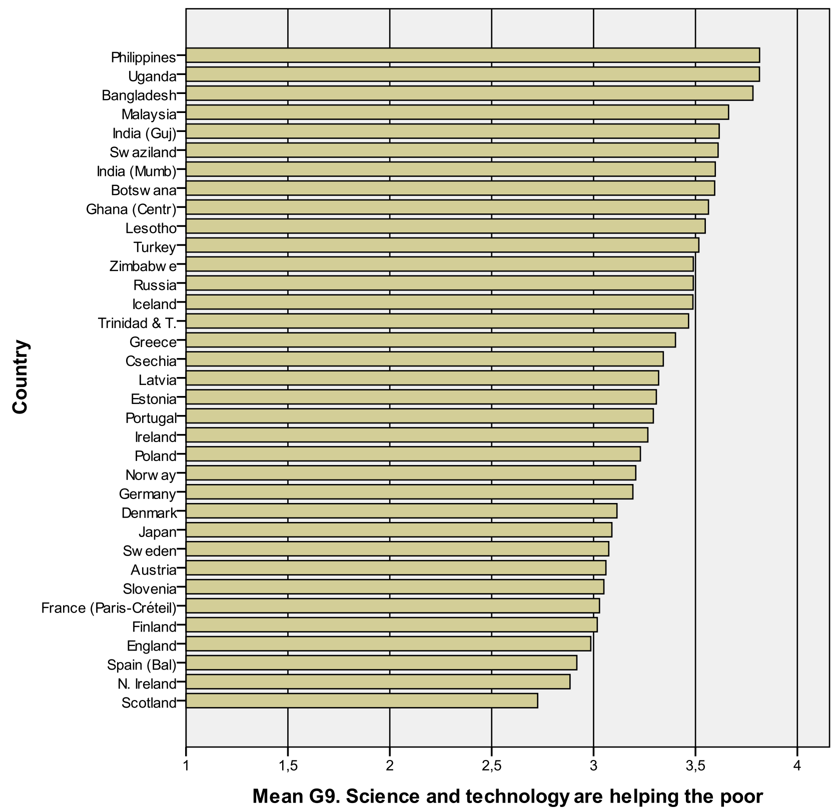
Mean G14. We should always trust what scientists have to say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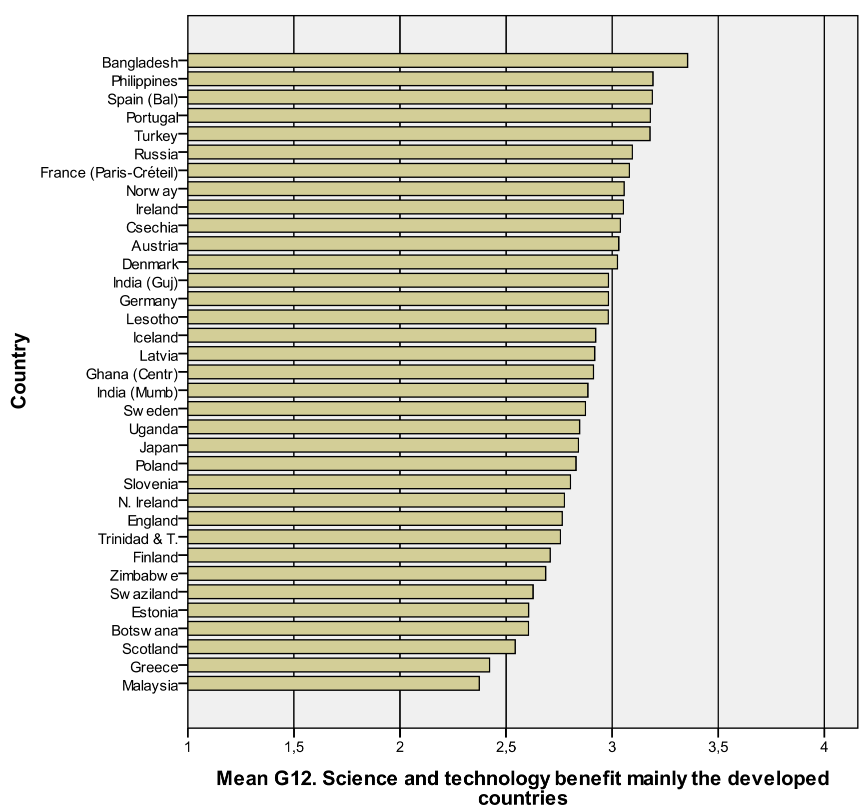
2,5
3
3,5
4
Mean G9. Science and technology are helping the poor


Country
Bangladesh
Philippines
Spain (Bal)
Portugal
Turkey
Russia
France (Paris-Créteil)
Norw ay
Ireland
Csechia
Austria
Denmark
India (Guj)
Germany
Lesotho
Iceland
Latvia
Ghana (Centr)
India (Mumb)
Sw eden
Uganda
Japan
Poland
Slovenia
N. Ireland
England
Trinidad & T.
Finland
Zimbabw e
Sw aziland
Estonia
Botsw ana
Scotland
Greece
Malaysia
1
1,5
2
2,5
3
3,5
4
Mean G12. Science and technology benefit mainly the developed countries