Kapitel 7: Young people's attitudes to science – Results and perspectives from the ROSE study

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Introduction[1]

The position of science and technology (S&T) in a society changes through time and from one society to another. In developing countries, many young people would like to opt for a career in S&T, while many rich and highly developed countries notice declining recruitment of students to science and technology studies. "Europe needs more scientists!" is the title of the final report from a large EU project addressing the condition of science and technology in the EU, with special attention to the number of people entering S&T educations and careers (EU 2004). The title of the report reveals the point: The falling recruitment to most S&T educations is seen as a large problem in most European countries. The same tendencies are noted in the US (NSB 2008) and in most other OECD countries. There is a great political concern about the decline in S&T recruitment in nearly all OECD countries (OECD 2006).

The lack of relevance of the S&T school curriculum is seen as one of the greatest barriers for good learning and as the reason for young peoples' low interest in the school subject and lack of motivation for pursuing the subject in their higher education. ROSE, The Relevance of Science Education, is an international comparative project meant to shed light on affective factors of importance to the learning of science and technology. The target population is students towards the end of secondary school (age 15). The research instrument is a questionnaire mostly consisting of closed questions with four-point Likert scales. The rationale behind the project, including the questionnaire development, theoretical background, procedures for data collection, etc., is described in Schreiner and Sjøberg (2004), available in print from the authors or from the project website.[2]In this article, the ROSE project and a few general results will be presented.

1 This article draws on material from Sjøberg andSchreiner 2011. For a more comprehensive overview, see Sjøberg/Schreiner 2010.
2 http://roseproject.no/.

ROSE in brief

The key feature of ROSE is to gather and analyse information from the learners about several factors that have a bearing on their attitudes to S&T and their motivation to learn S&T. Examples are: a variety of S&T-related out-of-school experiences, interests in learning different S&T topics in different contexts, prior experiences with and views on school science, views and attitudes to science and scientists in society, future hopes, priorities and aspirations as well as young peoples' feeling of empowerment with regards to environmental challenges, etc.

ROSE has, through international deliberations, workshops and piloting among many research partners, developed an instrument that aims to map out attitudinal or affective perspectives on S&T in education and in society as seen by 15 year old learners. The ROSE advisory group comprises key international science educators from all continents. We have tried to make an instrument that can be used in widely different cultures. The aim is to stimulate research cooperation and networking across cultural barriers and to promote an informed discussion on how to make science education more relevant and meaningful for learners in ways that respect gender differences and cultural diversity. We also hope to shed light on how we can stimulate the students' interest in choosing S&T-related studies and careers – and to stimulate their life-long interest in and respect for S&T as part of our common culture.

About 40 countries are taking part in ROSE, and many more have shown an interest in the project. The ROSE instrument is used for many different educational purposes in these countries. ROSE research partners (persons and institutions) were "recruited" through international networks and organizations for science education research and have met at conferences like ESERA (European Science Education Research Association) and IOSTE (International Organization for Science and Technology Education), and special ROSE workshops have been hosted in several European countries and in Malaysia. The data from the following 34 countries were found to meet the criteria for data quality and are included in the comparative analysis: Austria, Bangladesh, Botswana, Czech Republic, Denmark, England, Estonia, Finland, Germany, Ghana, Greece, India (Gujarat), Iceland, India (Mumbai), Ireland, Japan, Latvia, Lesotho, Malaysia, N. Ireland, Norway, Philippines, Poland, Portugal, Russia, Scotland, Slovenia, Spain, Swaziland, Sweden, Trinidad, Turkey, Uganda, Zimbabwe. In most countries the target population is the whole national cohort, but in some countries the ROSE target population is defined as the students in one *region* of the country (e.g. Karelia in Russia, Gujarat in India and the Central region in Ghana). In addition, many countries (e.g. Brazil, Taiwan, Italy, France, Israel) have published national reports, although their data have not been incorporated in the international data file.

The participating researchers in different countries were requested to apply random sampling methods as described in a handbook that was developed by the Norwegian organizers in cooperation with the international advisory team. For various reasons, e.g. due to limited financial resources, some countries have not been able to comply with the request. This means that not all of the 40 participating countries have samples that without reservation can be regarded as representative for 15 year old students in the country.[3]

ROSE has been supported by *The Research Council of Norway, the Ministry of Education in Norway, the University of Oslo*and the newly established *National Centre for Science Education.* Industrialized countries have covered their own expenses, while some funding for data collection was provided for developing countries and countries with less available ressources. Participation in the project has in many countries led to the release of local funding for the participants.

The ROSE material may illuminate a range of important and topical discussions in the science education community, for example issues such as curricular content vs. students' interests, cultural diversity, students' disenchantment with their science classes and students' perceptions of science in society, gender differences. Discussions on such issues have been taking place in many papers and conference presentations based on the ROSE material (see e.g. Jenkins 2005, Jidesjö/Oscarsson 2004, Lavonenet al. 2005, Ogawa/Shimode 2004, Trumper 2004). About 10 PhD students and several Master students are basing their thesis on ROSE data. The first PhD-thesis based on ROSE was presented in Norway (Schreiner 2006), the second in Ghana (Anderson 2007), a third in Sweden (Oskarsson 2012).

In the following, we will report some results from analyses of the ROSE material. All diagrams show mean scores for girls and boys from a number of countries in the ROSE sample. The countries are sorted partly geographically, with neighbouring countries together; and partly by level of development, using the Human Development Index as a proxy.

The Likert scales have four response categories, and the response categories vary from one question to another. Question groups A, C and E have the heading: *What I want to learn about*. These questions are inventories of possible topics to learn about, each with a 4-point scale. The extreme categories in the scale are labeled *Not interested* (coded 1) and *Very interested* (coded 4). It is a rather lengthy question with a total of 108 items. In order to avoid fatigue from the students, the items were grouped into three groups: question A, C and E; from now referred to as *question ACE*.

Other questions have a list of statements, and the students were asked to indicate on a 4-point scale whether they *Disagree* (coded 1) or *Agree* (coded 4). In the

3 National reports on how the survey was organized in each country are available from the ROSE website http://roseproject.no/.

following graphs, this scale is collapsed by presenting the code 3 and 4 as "agree" and the responses are given in percent of the total.

Similarities between countries

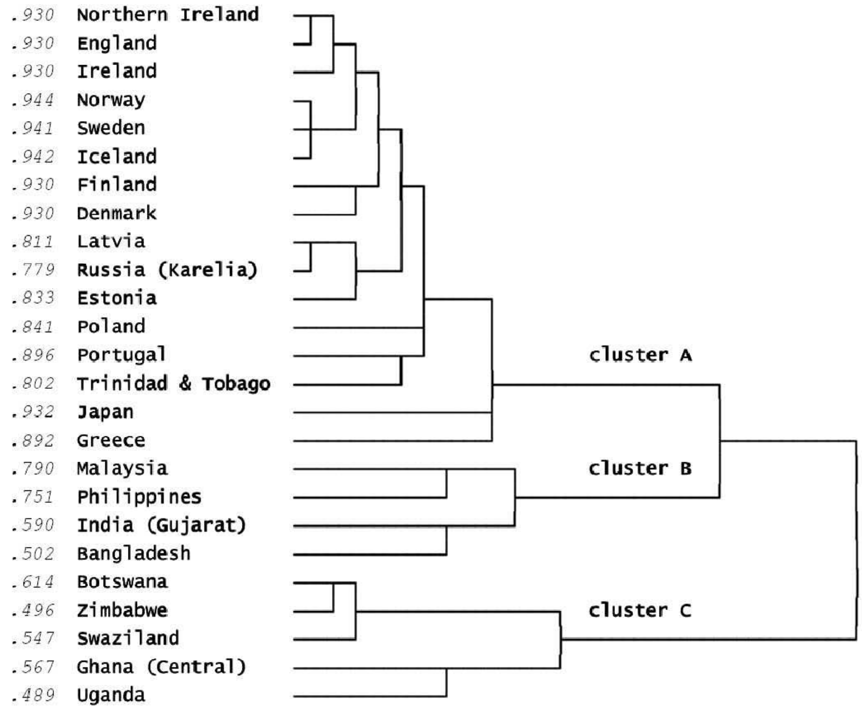
In question ACE we request the students to indicate how interested they are in learning about a variety of topics. One underlying hypothesis for this question is that in spite of few students choosing an S&T education and career, and in spite of research finding that many students do not like school science, many young people find aspects of S&T interesting. The ACE question provides empirical data on what topics various groups of students are interested in learning about. This insight can inform our discussions on how S&T curricula can be constructed in order to meet the interests of different groups of learners. Asking the students how interested they are in various topics is one approach for getting in touch with science lessons' potential for engagement.

We do of course not argue that science curricula should be determined from student opinion polls on what they find interesting. But, on the other hand, we believe that the teaching of school science has the potential to enliven, motivate, enrich, engage and inspire the students. To achieve this, we need to be aware of the interests, hopes and priorities of the learners.

For exploring similarities between countries in the ACE items, hierarchal cluster analysis is a useful explorative statistical tool. Results from the hierarchical cluster analysis can be presented in *dendrograms*. The dendrogram in Figure 1 below shows how similar or close the countries and country clusters are to each other: The branches illustrate how clusters are formed at different stages in the analysis and the distances between the clusters.

The distance along the horizontal axis from the point at which the clusters come into existence to the point at which they aggregate into a larger cluster represents the distinctness of the clusters. The distinctness tells us how different one cluster is from its closest neighbour. The more compact a cluster is, i.e. the further to the left the branches merge, the more similar to each other the countries are.

Figure 1. Hierarchical cluster analysis of residual ACE ("What I want to learn about") mean scores for all countries. Proximity measure: squared Euclidean distance. Clustering method: between-groups linkage. To the left, we have inserted a column showing the national HDI (Human Development Index) values (UNDP 2004, Schreiner 2006)



Annually, the United Nations Development Programme (UNDP) publishes a Human Development Report (HDR) (UNDP 1990-2011). In each HDR, the countries are ranked according to a Human Development Index (HDI). The index is monitoring average national achievement in three dimensions of human development: income, education and health.[4] In this article, the HDI-value (based on data from

4 The HDI is a summary measure of human development based on the weighted average of three indices: (1) a long and healthy life, as measured by life expectancy at birth, (2) education, as measured by the adult literacy rate (two-thirds weight) and the combined primary, secondary and tertiary education gross enrolment ratio (one-third weight), and (3) a decent standard of living, as measured by GDP per capita (PPP US$). (For details on how the index is calculated, see e.g. Technical note 1 in e.g. UNDP 2008).

2004) will be used as an indicator for the level of development in a country. To the left in Figure 1, we have inserted a column showing the national HDI values.

By reading the dendrogram from the left towards the right, we see that the meta-cluster contains three main clusters: (A) High HDI countries including all the European countries plus Japan and Trinidad and Tobago, (B) Medium HDI Oriental countries and (C) Low HDI African countries. As the length of the branch for all these three clusters is relatively long, they can be perceived as three distinctive clusters of countries. Cluster B is more similar to cluster A than cluster C is.

One noticeable result from the analysis above is that similarities between countries in this part of the questionnaire seem to be determined by two properties: geographical closeness and level of development. The general pattern is that first, the countries merge with geographically neighbouring countries, and next, the group of neighbouring countries merge with groups of countries having a comparable level of development.[5] But the unifying effect of geographical closeness only works within a certain limit of diversity in development. For example, Japan is geographically closer to the Philippines and Malaysia than to Europe, but the Japanese students seem to have more interests in common with European students. This may possibly be explained by the relatively high level of development and industrialisation in Japan. The response profiles of students in the Oriental countries (like Malaysia, Philippines, India and Bangladesh) appear as relatively similar to each other. We should note that the Russian students' orientation towards science and science education appear as comparable to the profiles of the students in the Baltic countries (Latvia and Estonia). Keep in mind that the Russian students in ROSE come from Karelia, a region quite close to the Baltic countries and Finland.

Most youth appreciate S&T in society

A possible explanation for young people's lack of interest for studying S&T could be that they hold a negative view of the role that S&T play in society, and that they blame S&T for the unintended catastrophes and risks (e.g. the Chernobyl disaster in 1986, BSE (Bovine Spongiform Encephalopathy or "mad cow disease"), the depletion of the ozone layer, global warming and overpopulation) following in the wake of the technological development (Beck 1999, Sjøberg 2009). Contrary to such expectations, the ROSE results indicate that youth express a positive view on S&T. Average scores for girls and boys in nearly all countries show strong agreement with statements like these:

5 In spite of non-random sampling procedures, countries that are commonly considered as similar to each other (for example African, Baltic or Asian countries) do in most instances show similar or related response patterns. This can be seen as some validation of the data.

• Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.,
• Science and technology are important for society,
• Thanks to science and technology, there will be greater opportunities for future generations,
• New technologies will make work more interesting,
• *The benefits of science are greater than the harmful effects it could have,* and
• *Science and technology make our lives healthier, easier and more comfortable.*

Figure 2: Science and technology are important for society. Percentage who "strongly agree" and "agree" for boys (male symbols) and girls (female symbols). Countries are sorted partly by level of development (HDI), partly by geographical proximity.

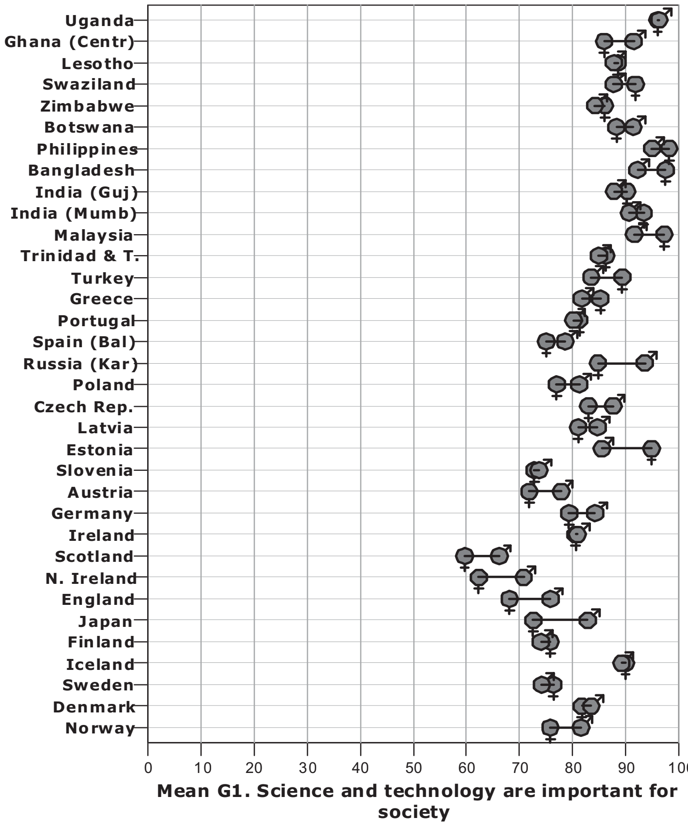


Figure 2 illustrates this with one example. The diagram shows responses to *Science and technology are important for society.* In average, girls and boys in all countries agree that S&T are important for society, and the gender differences are negligible.

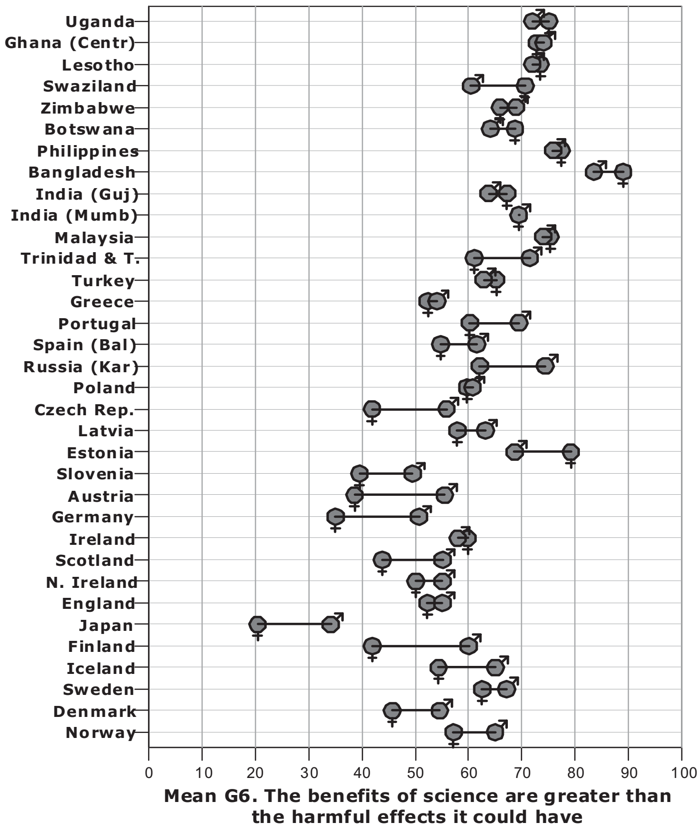
In general, youth in developing countries are very positive,. while young people in some of the wealth countries are more hesitant. Gender differences are rather small in most countries on this question.

The response is rather different for the statement *The benefits of science are greater than the harmful effects it could have*, shown in Figure 3. Here we note that the responses are much less positive in wealthier countries, and that the gender difference is considerable, girls are much more skeptical than boys. The most remarkable results are, however, the responses from the Japanese youth. Also on other questions of the same nature, they indicate a considerable higher degree of skepticism towards the role of S&T in society than youth from other countries.

The rather negative or reluctant attitudes of the Japanese youth towards S&T has gained considerable attention, for example in the Japanese newspaper Ashanti in December 2004. ROSE-data with a focus on Japan were also presented at the Science Agora in Tokyo in 2008.[6]

6 Available on http://www.ils.uio.no/english/rose/network/countries/norway/eng/nor-sjoberg-japan2008.pdf

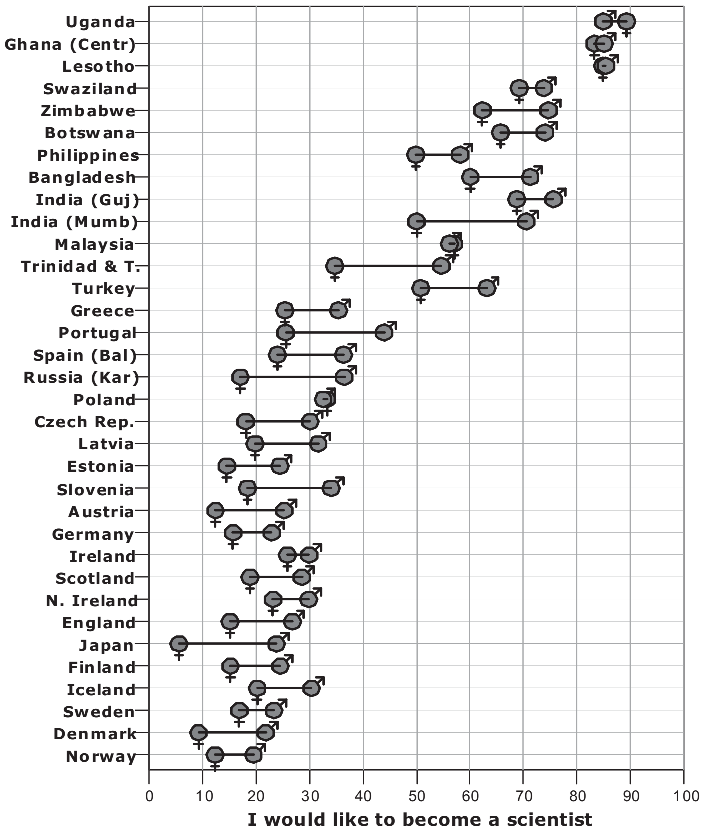
Figure 3. The benefits of science are greater than the harmful effects it could have. Percentage who "strongly agree" and "agree" for boys (male symbols) and girls (female symbols). Countries are sorted partly by level of development (HDI), partly by geographical proximity.



A future job in science or technology?

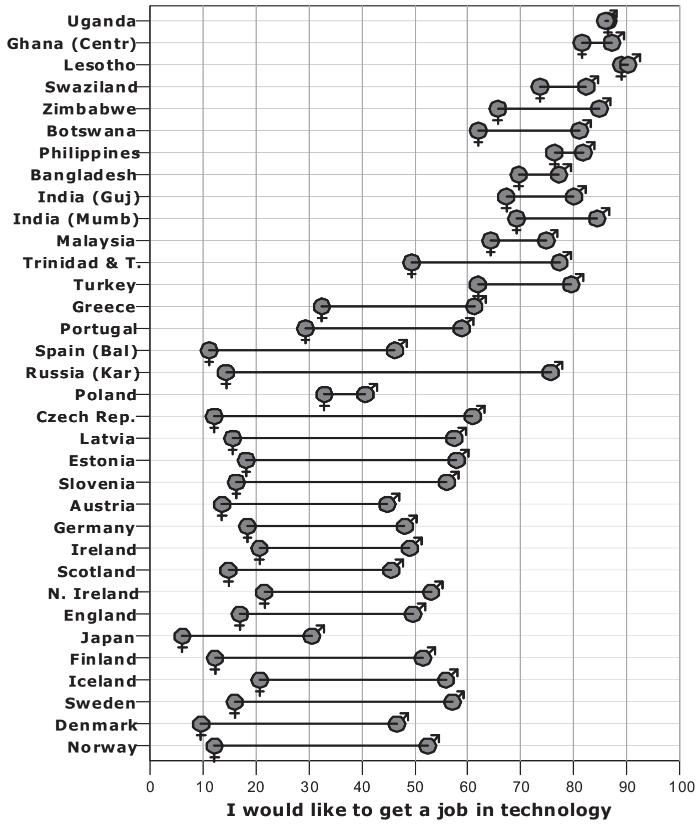
As mentioned, there is a widespread concern about the recruitment to the S&T sector. Many questions address this issue, and here we only present results from single items on this issue. We see from Figure 4 that there are large cross-national differences when it comes to students' agreement with the statement *I would like to become a scientist.* The mean scores in the developed countries are extremely low, and the girls are even more negative than the boys. Japan has particularly large gender differences.

Figure 4. I would like to become a scientist. Percentage who "strongly agree" and "agree" for boys and girls. Percentage who "strongly agree" and "agree" for boys (male symbols) and girls (female symbols). Countries are sorted partly by level of development (HDI), partly by geographical proximity.



Responses to the item *I would like to get a job in technology* are illustrated in Figure 5. Also in this diagram, we note pronounced differences between countries and between girls and boys in each country. While boys in more developed countries give average scores close to the neutral value, most girls in these countries do *not* want to work with technology. In developing countries, both girls and boys agree with the statement. Also in these countries, there are some gender differences, but they are by no means as large as in the developed countries.

Figure 5. I would like to get a job in technology. Percentage who "strongly agree" and "agree" for boys and girls. Percentage who "strongly agree" and "agree" for boys (male symbols) and girls (female symbols). Countries are sorted partly by level of development (HDI), partly by geographical proximity.



Orientations towards S&T: linked to the level of development in a country

Young people's values, views and ways of understanding themselves, their surroundings and the world are products of the culture in which they are growing up. Our data show a strong relationship between the HDI for a country and the responses in the ROSE questionnaire. For example, the national average score across all items in the ACE question (*What I want to learn about*), the Pearson product moment correlation coefficient with HDI is -.85 ($p < .01$), which indicates a very strong inverse relationship: The higher the level of development in a country is, the lower interest the students express in learning about S&T-related topics, although there are some interesting outliers.

Figure 6. Country means of interest in learning science vs. level of development measured by HDI, Human Development Index. Scatter-plot with regression line: HDI values (horizontal axis) and the national average score across all items in the ACE question (vertical axis) for all countries. Pearson product moment correlation coefficient is -.85.

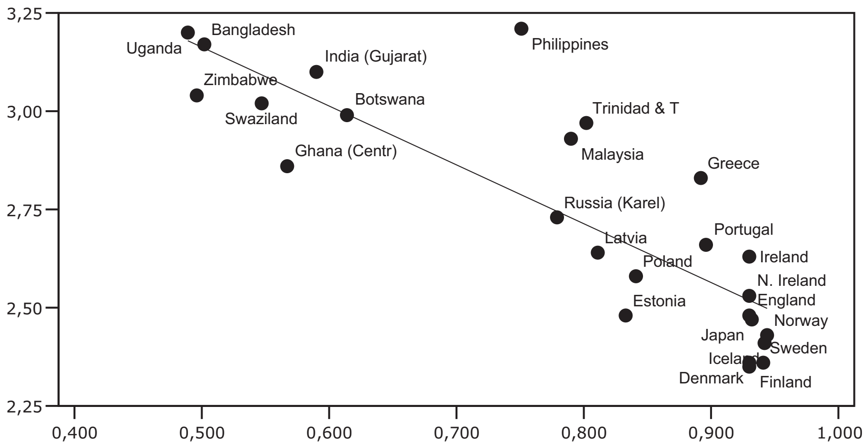


Figure 6 shows that the ACE mean for some of the countries in the extreme low end of the HDI scale lies one unit (in a scale with a span of three units) above many countries in the extreme high end of the HDI scale. In most of the ACE items, students in countries like Uganda and Bangladesh express much more interest in learning about the topics than students in more developed countries like Norway, Iceland, Finland and Japan. Also in the Philippines, youth express a general high level of interest.

The correlation coefficients for the four questions reported in Figure 2 to Figure 5 are given in Table 1. The table indicates the general pattern appearing from most analyses of the ROSE material: The more developed a country is, the less positive young people are towards the role of S&T in society.

Table 1. Pearson product moment correlation coefficient of mean agreement with statements with HDI (p<.01).

Item / Issue	R (Pearsons)
I would like to become a scientist	-0.94
I would like to get a job in technology	-0.91
Science and technology are important for society	-0.78
The benefits of science are greater than the harmful effects it could have	-0.73

Quelle: Daten aus der ROSE-Studie

We see from our data that whether young people wish to opt for a career in S&T is closely related to the country's level of development. An important challenge in poor countries is of course related to the betterment of material conditions, economic growth and to the improvement of health and the welfare system. Further material development of the society is naturally a main political and public issue, and in this respect S&T are seen as fundamental driving forces. One may assume that in such societies, a job in S&T is perceived as important for society and thereby as meaningful for the individual.

When today's modern societies were in the era of early industrialisation, the focus was directed towards *progress*, *growth* and *building the country*. Consequently, exactly this – to build the country – was perceived as important for the society and meaningful for the individual. It may be that we now have passed the era in which the work of physicists, technicians and engineers is seen as crucial for people's life and well-being in the more developed countries. Other studies also indicate that in poorer countries, young people have a rather heroic image of scientists as persons, while this is not the case in highly developed Western societies (Sjøberg 2002). In modern societies, neither scientists nor engineers are heroes or attractive role models for the young generation.

Obviously, the level of development influences people's expectations to the expected benefits of developments in S&T (Sicinski 1976). The Eurobarometer (EU 2005) also shows that the belief in the benefits of S&T is much stronger in the less developed EU countries than in the wealthier and more developed.[7] According to Inglehart (1990), late modern societies can be characterised as post-materialistic societies emphasising values like environment, democracy, care for others, self-actualisation, etc. The recruitment of Western students to medicine, biology and environment studies are *not* falling, and in these subjects the girls often outnumber

7 The Eurobarometer (EU 2005) collected data in 32 countries: the 15 "old" EU countries, the 10 new member states (previously Eastern Europe), the four "candidate countries" Turkey, Croatia, Bulgaria and Romania and the three EFTA countries Iceland, Norway and Switzerland.

the boys. This may indicate that youth in more developed countries believe that the most important challenges facing our society are related to health and environmental issues, and, consequently, that these fields can offer meaningful jobs.

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