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Organisation for Economic Co-operation and Development

Global Science Forum

Evolution of Student Interest in Science and Technology Studies
Policy Report

EXECUTIVE SUMMARY

A working group on the declining interest in science and technology (S&T) studies among young people was established by delegates to the Ninth Meeting of the Global Science Forum in July 2003, based on a proposal from France and the Netherlands. It was agreed that there was a need for an OECD-wide analysis to determine whether any real decline could be measured, and to study the causes and possible remedies. The consensus findings and recommendations of the working group are summarised below.

In recent years, Science and Technology student numbers have been increasing in absolute terms, but decreasing in relative terms.

Findings: Over the past 15 years, most OECD economies have experienced a large increase in the number of students in higher education. The absolute number of students in S&T fields shows an overall increase too, but the proportion of S&T students has steadily decreased during the same period. Some disciplines, such as mathematics or physical sciences, show particularly worrying trends.

Recommendation: In-depth studies of the possible impact of current trends in student enrolments should be undertaken by OECD countries to analyse the evolution of supply and demand in view of the expected stabilisation of student numbers in higher education, and the continuing transition to a more technology-intensive economy.

Existing statistical data are not fully adequate for measuring and analysing levels of student interest.

Findings: Despite recent efforts to harmonise statistical information on education at the international level, current data sets do not allow for a full analysis of the situation, and may lead to conflicting interpretations. Furthermore, data on student numbers do not necessarily reflect the actual interest of students for S&T disciplines, as other factors (such as the number of positions available in S&T higher education), also influence enrolment numbers.

Recommendations: The consistency, significance, scope and coverage of quantitative indicators should be improved through international consultation and agreements. Ongoing, long-term studies of student motivation, using specific indicators, should be promoted.

Women are still strongly under-represented in S&T studies.

Findings: Although the number of female students in tertiary education has increased more rapidly than that of males, the proportion of women choosing S&T studies still remains below 40% in most OECD countries. The choice of discipline is highly gender-dependant, and fields such as engineering or computing sciences are largely male-dominated. These choices may be linked to the negative pressures and external expectations affecting female students. Persistent stereotypes weigh heavily on female student choices throughout their education (a phenomenon that can also affect minority students).

Recommendations: Since increasing the number of female students appears to be the most obvious way to increase the overall number of S&T students, governments should actively promote equal opportunity, and should take steps to eliminate negative stereotypes.

Student choices are mostly determined by their image of S&T professions, the content of S&T curricula and the quality of teaching.

Findings: Student decisions about study and career paths are primarily based upon interest in a particular field, and on their perception of job prospects in that field. Educational content and curricula play an important role in raising and maintaining young people's interest in S&T. Positive contacts with science and technology at an early age can have a long-lasting impact. Negative experiences at school, due to uninteresting content or poor teaching, are often very detrimental to future choices. Furthermore, curriculum structures can also play an important role in preventing pupils from pursuing their natural preferences. Accurate knowledge about S&T professions and career prospects are key elements of orientation, but are currently fraught with stereotypes and incomplete information. Science and technology face increasing competition for good students from new, more fashionable subjects in higher education.

Recommendations: Provision of accurate information is an important aspect of any policy to increase the attractiveness of S&T studies and careers. This encompasses not only the information provided to students but also interactions between all the stakeholders (education, scientists, business, etc.). Governments and relevant institutions should also provide adequate resources for teacher training and classroom activities. Flexible, more attractive curriculum structures with updated S&T content should be devised. As many governments and other bodies undertake actions to promote S&T career paths, the exchange of information on best practices and evaluation tools assumes even greater importance.

Introduction

The evolution of student enrolments in science and technology at various levels of the education system has been an issue of considerable interest in many OECD countries over recent years, given that the economy is increasingly driven by complex knowledge and advanced cognitive skills. The Global Science Forum authorised an activity on the subject at its Ninth Meeting in July 2003. This issue was identified as an OECD priority as a result of the ministerial meetings of the OECD Committee for Scientific and Technological Policy (January 2004), and of the Education Committee (March 2004).

Based on the recommendations of a steering committee (chaired by Professor Jean-Jacques Duby of France), presented at the Global Science Forum meeting in July 2004, a working group was established, composed of representatives from 16 countries, the European Commission and the OECD Secretariat, and chaired by Professor Sjoerd Wendelaar Bonga of the Netherlands. Statistical data on student enrolments and graduation rates were submitted by 19 countries, and analysed together with information on factors contributing to possible declining interest and solutions attempted in different countries.

The Working Group's preliminary results and recommendations were presented and debated during an international conference co-organised by the OECD Global Science Forum and the Ministry for Education, Culture and Science of the Netherlands in Amsterdam on 14-15 November 2005.

The present report summarises the main findings and recommendations from the working group following this conference. The detailed analysis of the statistical data, causal factors, and solutions implemented will be published in a separate, longer document.

Objectives

The overall goals of the Global Science Forum activity were:

1. To analyse quantitative trends in enrolments in S&T studies during recent years (and, in particular, to quantify the extent of any decline).
2. To identify the underlying factors that affect students' choices.
3. To explore solutions that can be implemented to influence such choices.

Secondary goals were to identify the limitations of the existing indicators and models of the complex phenomena involved, and to explore the need for extended data and information sharing.

The study did not address the potential impact of a decline on national economies and on society in general, nor the relationships between supply and demand for S&T students.

1. Quantitative trends in student choice for S&T studies

A new data-gathering exercise was undertaken for this GSF activity, since the current international statistical system presents serious limitations. For instance, such data were previously available only for the tertiary level, and data by field of study were limited in detail and time span. Further complicating matters, the revision of the ISCED (International Standard Classification of Education) in 1997 introduced a discontinuity in the data when changes were made in the definitions of educational levels and disciplines.

The statistical data gathered in this OECD study concern the following five areas: life sciences, mathematics and statistics, physical sciences, computing sciences, and engineering. Data were compiled in four categories: secondary level/high school diplomas, entrants in tertiary education, tertiary graduates, and doctorates. Academic and vocational studies data were aggregated. When available, data were also analysed by gender and by national/foreign origin. The time span is 1993-2003 for most data categories, and 1985-2003 for some others.

Data were obtained for nineteen countries: Australia, Belgium (Flanders & Wallonia), Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, the Netherlands, Norway, Poland, Portugal, Sweden, Turkey, the United Kingdom, and the United States.

Analyses of trends in student choice for S&T studies have to take into account demographic trends as well as better access to higher education. Most countries have experienced a significant decline in their 15-19 year-old population, with only a few exceptions (such as in the US), although this decline has been reversed in very recent years in a few EU countries. Overall, declining demographic trends have usually been counterbalanced by better access to upper secondary education, leading to a small to moderate increase in the number of upper secondary graduates in the countries analysed.

Similarly, enrolment rates in tertiary education increased over 1995-2003 in all the countries analysed, often very significantly. Higher access rates have largely overcome negative or stable demographic trends. Thus, in 10 of the 19 countries studied, the absolute numbers of tertiary students increased by over 30%.

Findings

A. An overall increase in the number of students in S&T

As a consequence of the growing enrolment rates in higher education in OECD countries, absolute numbers of students in S&T increased in most countries over 1993-2003 (Figure 1). This is true for the different stages of tertiary education (entrants, graduates, doctorates), except for secondary graduates with a scientific orientation for which (although data are not available for all countries), the trend has been more uneven in recent years. However, these data hide very important disparities between countries and, even more, between different fields of study.

B. A downward trend in relative terms

While absolute numbers of S&T students have been rising, the situation is exactly the opposite with regards to the relative share of S&T students among the overall student population during the same period (Figure 2). This is true not only in tertiary education, but also for upper secondary graduates in many countries (Figure 3). Coupled with unfavourable demographics and a stabilisation of the number of students accessing tertiary education, several OECD countries can expect this general trend to affect the *absolute* number of S&T students in future years. In other countries, a demographic recovery would mitigate this trend.

C. Some disciplines are particularly affected

Aggregate numbers hide important differences among disciplines. Engineering students account for 40% to 60% of S&T students in most countries, especially at the new entrant and graduate levels, and are characterised by a stable or positive enrolment trend over the past 10 years. The situation for physical sciences and mathematics is the opposite (Figure 4): a decline is often seen in the absolute number of students. In some countries, the proportion of students in such fields was halved between 1995 and 2003. On the other hand, the proportion of students in the life sciences and in engineering has remained mostly stable, due primarily to an increasing number of female students in the life sciences, and to a growing interest in types of studies – such as engineering – that have good job prospects. The number of computer science students has increased dramatically. This particular evolution may be the consequence of shifts in student choice within the overall domain of S&T, e.g., from physics to computer studies.

Recommendations

Given that enrolments are declining in certain fields, governments of OECD countries need a better understanding of the impact of this phenomenon on their economies and on society in general. Specifically, the Global Science Forum activity described here should be followed by a complementary effort to understand future demand for S&T graduates at all levels. The comparison of the likely supply and demand would determine the urgency of undertaking new efforts to change enrolment numbers.

2. Limits of the quantitative analysis

The quantitative study encountered significant limitations and obstacles, largely because it relied on specific national data sets. Ideally, an optimal analysis of student numbers would be based on complete sets of homogeneous data, in which countries would apply identical (or very similar), definitions of diplomas, educational levels, student categorisations, etc. Moreover, these definitions would be stable over time. Since this is not the case, the analysis was often limited to comparisons of trends and ratios, rather than of absolute numbers.

Extrapolating student interest in specific disciplines from numbers of students in S&T studies must also be done with caution, as the relationships among numbers, choices, and the degree of interest in S&T studies are complex and indirect.

Findings

A. Heterogeneity in data sets limits the interpretations and may lead to conflicting conclusions

The statistics used in this study are not satisfactory for an exhaustive in-depth analysis of the situation at an international level. Few countries were able to provide the complete information set requested, principally because of changes in classification, or unavailability of breakdowns by scientific discipline. This was particularly the case for upper secondary graduates.

Despite the existence of the ISCED classification system for the various disciplines (revised in 1997), many countries do not have homogeneous data. Not all countries compile data using the ISCED definitions, and those that do sometimes interpret them differently (and even change these interpretations over time). These discrepancies make analyses of absolute numbers unreliable, particularly since graduates are sometimes double-counted, as the indicators cover the total number of graduations in a year, rather than the number of persons graduating (some students get more than one diploma in a year). This can result in overstated total numbers or growth rates. It is also difficult to compare the evolution of specific disciplines between countries, and the analysis of trends over the years for various categories of students suffers from discontinuities. A similar situation exists for “foreign” or “minority” student categories.

B. Enrolment data do not necessarily reflect student interest or motivation

The quantitative study analyses trends in the number of students studying S&T subjects, but this is not necessarily a complete measure of the possible decline in the number of students interested in S&T studies. For instance, as S&T are prestige subjects, a decline in interest may not translate immediately into a decline in enrolment if the number of S&T places is limited. There may still be more than enough applicants with the necessary qualifications for the number of places available, even though the actual number of applicants is declining. Thus, a decline in the number of people wanting to study science may not result in an actual decline in enrolments. For this reason, the decline in interest in science studies may be stronger in some cases than that recorded in enrolments. Motivation surveys, which measure the actual interest of young people in various fields of study or the reasons behind their choice, are usually conducted as one-off studies, or (as in PISA), repeated at very long intervals. These studies, while providing important qualitative information, do not permit adequate quantitative assessment of interest or motivation.

Recommendations

- The consistency, significance, scope and coverage of quantitative indicators are being improved under the aegis of INES work (Indicators of National Education Systems). This endeavour should be further encouraged. To correctly evaluate trends, countries should make strong efforts, at international level, to measure the same elements that correspond to specific indicators. For example, there is a need for a clear distinction between numbers of graduations/diplomas and of graduate students, or a better definition of "foreign students". The new ISCED definitions used in education statistics are extremely valuable, but further improvements could be made, for example finer distinctions between science and engineering, or taking into account hybrid disciplines (such as biomedical engineering). Such measures would help countries that do not yet have statistical information by field of study to undertake such data gathering. Better metadata and specific data on new entrants should be compiled.
- New entrant and graduation data alone are insufficient for monitoring student interest in S&T studies. Such information is nevertheless very important, not only to analyse the phenomenon itself, but also to measure the efficacy of any new policies. Appropriate analytical models and indicators should therefore be defined at international level. These could be linked, for example, to analysing the number of candidates for S&T study positions and/or academic levels rather than just enrolment figures (in countries that apply a selective entrance examination to universities); measuring drop-out and switch rates; and acquiring information on the choices made by the best students (who traditionally chose S&T disciplines). International surveys (such as PISA or ROSE), that include questions on student motivation should do so over long periods, to make trend analyses possible.

3. Women are still strongly under-represented in S&T studies

Female students are the most obvious resource for increasing S&T enrolments. In some respects, this is also true for young people coming from some minority groups in OECD countries, and the factors that affect their choice or success in these disciplines overlap. However, these issues are difficult to act upon, as a number of complex interactions are involved, including social and economic factors.

Many surveys have shown clear differences between boys and girls in their experience with, interest in, and attitudes to science and engineering, so it is not surprising to see these attitudes transposed into differences in their choice of studies. Furthermore, girls tend to show a stronger interest in people rather than facts or "things", and these differences are amplified in the way S&T are taught, and in the perception of S&T careers. These differences do not appear to be related to ability, since girls tend to succeed well in S&T, especially in the early stages. Some experts are working on the re-engineering of the education process to offer equal opportunity to both genders, but no consensus has yet emerged concerning the assumptions, methods, or results that can be achieved.

Some minority students are poorly represented in S&T studies, although detailed analyses are missing for many countries. The low rate of pursuit and high dropout rate is a concern in several OECD countries, although socio-economic considerations, as well as differences in cultural and environment factors, make for complex and difficult analyses and solutions.

Findings

A. *The share of women in S&T studies is increasing, but has not yet caught up with that of men*

The number of female students in tertiary education has increased more rapidly than that of males, but the proportion of women choosing S&T studies is still lower than that of men (Figure 5). Furthermore, even if the share has often increased more clearly in countries that had the lowest proportion of female S&T students, trend analysis suggests that the proportion of female S&T graduates may hit a 40% "glass ceiling" even in the most "effective" countries, perhaps due to a selective choice of females for some specific fields.

B. *Choice of discipline is highly gender-dependent*

In most countries, women constitute less than 25% of computing and engineering students. In contrast, women are systematically more numerous than men in life sciences (Figure 6). The percentage of female students is fairly homogeneous within each discipline in the countries analysed. However, trends in female student entrants or graduates within each field differ strongly between countries.

C. *Girls (and minority students), are subject to negative pressures and stereotypes*

Young female students suffer from stereotypes in relation to external expectations (those of parents, teachers, and society in general). Despite having marks at least as good as boys, girls are usually not encouraged to pursue S&T career paths by their families, teachers, and career advisors. The teaching process tends to reflect the same stereotypes: for example, boys are praised for creativity and imagination, but girls for more mundane achievements such as hard work or perseverance. Girls tend to undervalue their own performance, and hence their ability to pursue S&T. They also lack role models (famous scientists, family members, etc.). Several studies have shown that having family models may strengthen confidence in girls' ability to undertake S&T studies. In certain respects, these stereotypes are also true for students belonging to some minorities. Both girls and minority students may find themselves isolated in the homogeneous, male-dominated majority group formed by students studying S&T.

Recommendations

- Female students should benefit from priority measures, as they constitute a large reserve of possible S&T students. However, this should preferably not be achieved via programmes that are targeted at "girls only" as such labelling often lowers their credibility for various stakeholders.
- Ideally, a uniform S&T educational system should be applied for all students, and should allow all students to achieve their full potential, without subtle or overt discrimination.
- Reforms are needed in teacher training, curriculum and role model development. The learning context and approach should be modified to make them more attractive to female students. For example, the benefits of S&T for society should be stressed.
- Multidisciplinarity and student interactions should be promoted.
- Mentoring projects should be encouraged to support women and minority students undertaking careers in S&T.

4. The image of scientists remains positive but S&T professions have become less attractive

Image and motivation surveys show that the perception of science and technology remains largely positive among young people. Science and technology are considered important for society and its evolution (more so by developing countries respondents than in OECD countries, according to the SAS and ROSE surveys), despite concerns in specific areas, often linked to negative environmental and societal consequences of S&T. Scientists are also among the professionals the public trusts most, even though their prestige has declined (higher management or government positions are rarely held by scientists or engineers, and media reports on S&T events do not focus on the researchers themselves, who are thus very rarely known by name).

Careers in S&T are still recommended by parents. However, there is a sharp difference between the positive opinion of young people towards S&T and their actual wish to pursue S&T careers. Although S&T professions continue to generate great interest among youth in developing countries, this is no longer the case for industrialised countries, with an even stronger distaste expressed by girls (except for health-related professions). Many young people have a negative perception of these careers and lifestyles. Incomes are perceived as low relative to the amount of work involved and the difficulty of the required studies. Few pupils have a full or accurate understanding of science-related professions, and many are largely unaware of the range of career opportunities opened up by S&T studies.

Findings

A. *Young people have only a vague idea, often stereotyped, of what S&T professions are*

Students often lack knowledge about what S&T professionals really do. What they do know often comes from personal interactions (mostly S&T teachers, or someone in the family), or through the media. Scientists are usually portrayed as white men in white coats, and engineers as performing dirty or dull jobs. As S&T professions evolve quickly, S&T teachers and career advisors often lack up-to-date information to convey to their students. Young people therefore have few opportunities to learn what S&T professionals actually do and what their lives are like. The careers of S&T professionals as a whole have suffered from reports in the media of poor prospects and funding and increased job insecurity, despite the fact that these phenomena apply primarily to researchers. In addition, the possibility of having a proper balance between a successful career and a fulfilling family life is important to young people, and is perceived as difficult in S&T professions.

B. *Positive decisions to pursue S&T studies and careers are often linked to better knowledge*

Several surveys suggest that having a parent or family member working in S&T increases the chance of a student choosing S&T. Students also indicate that professional contacts have a strong impact on their choices. This is especially important for girls who lack adequate role models in these professions. The decision to choose S&T studies also depends on students' knowledge of careers outside traditional S&T professions. Thus, many students are sensitive to the range of professions opened up to them by various educational channels, and tertiary-level S&T studies are often wrongly perceived as leading to a very narrow choice of technical careers.

C. *The impact of communication on S&T needs to be better assessed*

Many initiatives have been launched at different levels to promote S&T careers and studies. Government action has often targeted the image of science and scientists in society (science weeks, science days, etc.), and many more undertakings come from professional scientific organisations. Communication tends to focus on science itself, not on the reality of S&T professions. The actual impact of the various actions on both young people's attitudes and their choices of studies or careers is poorly evaluated, however. Furthermore, communication between the various stakeholders is often inadequate.

Recommendations

- Students must have access to information about S&T careers that is accurate, credible, and avoids unrealistic or exaggerated portrayals. It should be compiled by independent observers, and made available to the education community, parents and students. Better information on S&T jobs should also be provided through direct contacts with professionals. Governments should earmark resources for such outreach actions, and for assessing their effectiveness.
- At the OECD conference, many participants insisted that follow-on actions need to engage all persons who are concerned by declining interest in science. A network of stakeholders (linking educational resource centres, the business community, S&T education specialists, and student and teacher communities), should be established to share information on best practices between countries and the various communities involved.

5. Science and technology education and curricula need to be reformed

Educational content and curricula are essential elements of students' choices. Declining enrolments are very often attributed to the uninteresting and difficult content of science courses.

The education system has to satisfy two conflicting demands, particularly at primary and lower secondary level. The first is to pass on the basic S&T knowledge that all citizens should possess, as well as making everyone familiar with scientific thinking, and developing curiosity and interest in science. The second is to provide detailed knowledge to potential S&T professionals. Whereas the first demand involves a more participative approach and focuses on interest, the second involves teaching more conceptual and challenging material. The difficulty is to use an appropriate mix of both types of teaching methods and subjects – a problem that has long been at the centre of the debate about science education.

Findings

A. Positive contacts with S&T at an early stage are essential

Students' educational and career choices are primarily based upon interest in, and even passion for, a particular field. Interest in S&T appears very early, in primary school, and longitudinal surveys suggest that this interest remains stable between the ages of 11 and 15. An even longer-lasting impact is likely, but is difficult to measure. Actions to promote early contact can be directed at teachers (to raise their confidence and increase the attractiveness of S&T); teaching content (hands-on experience for students); and the pupils (extracurricular activities, communication, etc.).

B. Poor opinions of S&T studies are often linked to negative educational experiences

Children in primary school have a natural curiosity for science and technology. However, many of their teachers lack initial training or are uncomfortable with science subjects and with hands-on demonstrations. Teaching often focuses on memorising rather than on understanding, as heavy workloads leave little time for experiments. At lower secondary level, pupils need to feel the relevance of the subject to society and to their own world. Unfortunately, what is taught is often disconnected from cutting-edge science and from today's applications of S&T, and tends to dampen the interest acquired at a younger age. Interest in S&T is observed as declining most sharply around age 15. This is also when gender differentiation starts to translate into choices, and when key future orientations are set. Regrettably, curricula are often too rigid to allow those pupils that do not choose to follow S&T fields as their primary subjects to come back to science at a later stage.

C. *In higher education, S&T have to compete with new, more fashionable subjects*

The disciplines that are most affected by lack of student interest are those with high theoretical content such as mathematics, physics and chemistry. At upper secondary and tertiary levels, S&T topics have to compete with new, more fashionable subjects (management, marketing, media studies, etc.), or vocational studies, which appear more relevant to the job market or to societal concerns. Apart from intrinsic interest, career prospects are the most important factor affecting young people's choices. Several experiments have shown that the number of students undertaking university studies can be increased by providing better information about S&T related careers, and by reforming and redefining tertiary programmes to reflect more relevant and more interesting content.

Recommendations

- Curricula need to be more flexible to offer a second chance to students who wish to come back to S&T studies following a different choice at an earlier stage. Providing such an opportunity has a proven effectiveness, with excellent success rates when studies are resumed. Positive incentives (such as grants or guaranteed access to university), can make the scheme more attractive.
- Curricula should be redesigned to better reflect the reality of modern science and technology, and to emphasise their contributions to society. Specific actions can focus on encounters with S&T professionals, exposure to cutting-edge science and technology and their applications in modern life, debates on the role and social relevance of S&T, and actions directed towards a "humanisation" of science teaching. Teaching should also concentrate more on scientific concepts and methods rather than on retaining information only. These goals are particularly important in secondary education.
- Professional skills and cross-disciplinary studies should be promoted in higher S&T education. Over-specialisation and the lack of elements of social dimension in the curriculum can deter some groups of students from pursuing tertiary S&T studies. In addition, skills such as communication, project management or teamwork are also increasingly valued in S&T careers. New programmes with an enlarged vision of S&T have proved to be more attractive to many students, especially young women.

6. Teacher training and qualification requires attention

The influence of teachers on future study and career choices of pupils is always cited as very important, particularly at primary and secondary level. In addition to transmitting knowledge, teachers provide career advice (explicitly or implicitly), and are themselves role models.

Teachers' initial and further training has an impact on teaching quality, but also on the motivational factors that influence student attitudes to science and technology studies. However, teachers frequently report that they lack the resources and opportunities to reflect upon their way of teaching and to increase their knowledge. In some countries, there are concerns about the fact it is increasingly difficult to recruit teachers in S&T.

Findings

A. *Insufficient knowledge of S&T may affect teacher confidence in S&T subjects*

In many of the countries studied, most primary teachers come from a non-S&T background, and many have not had any specific professional training in S&T. This can also be true in secondary education if teachers are required to teach subjects for which they lack competence. At primary level, teachers are expected to transmit the essence of the scientific method and to awaken the interest and enthusiasm of their pupils, but this is difficult when they themselves are uncertain about the subject and their knowledge of it, something which the pupils sense.

B. *Teachers need up-to-date S&T knowledge and information on S&T careers*

Science and technology are fast-evolving subjects, and in many countries the average age of secondary teachers is high. Further training on recent developments is often lacking or does not focus on theoretical subject content. As a result, and despite the fact that they are often very motivated by their work, many S&T teachers may need to update their knowledge and may not be at ease with the latest S&T developments, which are of the greatest interest to the students. Scientific careers are evolving rapidly as well, but most teachers do not have access to information on career prospects for S&T students and are therefore reluctant to offer career advice.

C. *Conveying a positive image of S&T requires skilled teaching*

Science and technology disciplines are usually perceived as difficult, and results achieved by students are frequently used as a general-purpose measure of overall ability, which generates anxiety among students and parents alike. It requires good teaching skills to overcome these hurdles, and to convey the great intrinsic value of S&T and the merits of S&T careers. However, S&T teaching staff are often recruited on the basis of competence in their specific subject, not in teaching as such. In many countries, recruitment does not include any requirement or further training in teaching skills. The problem is especially acute in tertiary education, where teachers are usually only evaluated on their research performance, which may lead to high drop-out rates.

Recommendations

- Incentives and resources must be provided to teachers who need training or refresher courses in S&T. These should be offered as part of a flexible framework of life-long learning. Teachers who make the effort to upgrade their skills and knowledge should be rewarded. This does not have to be financial - it could take the form of sabbatical leave for example. Specific initial training should also be provided, to raise the teacher's awareness of stereotypes that can be unconsciously transmitted to pupils, and particularly to female and minority students. Rewards should also be provided to teachers and academics who invest their time in S&T communication.
- Networks of teachers, from primary to university level, should be set up by teachers' associations and education ministries to share information on requirements and teaching practices in S&T studies. Although the context differs according to level of education, there are common features and lessons that should be discussed and shared among teacher communities.

Appendix 1

Figures

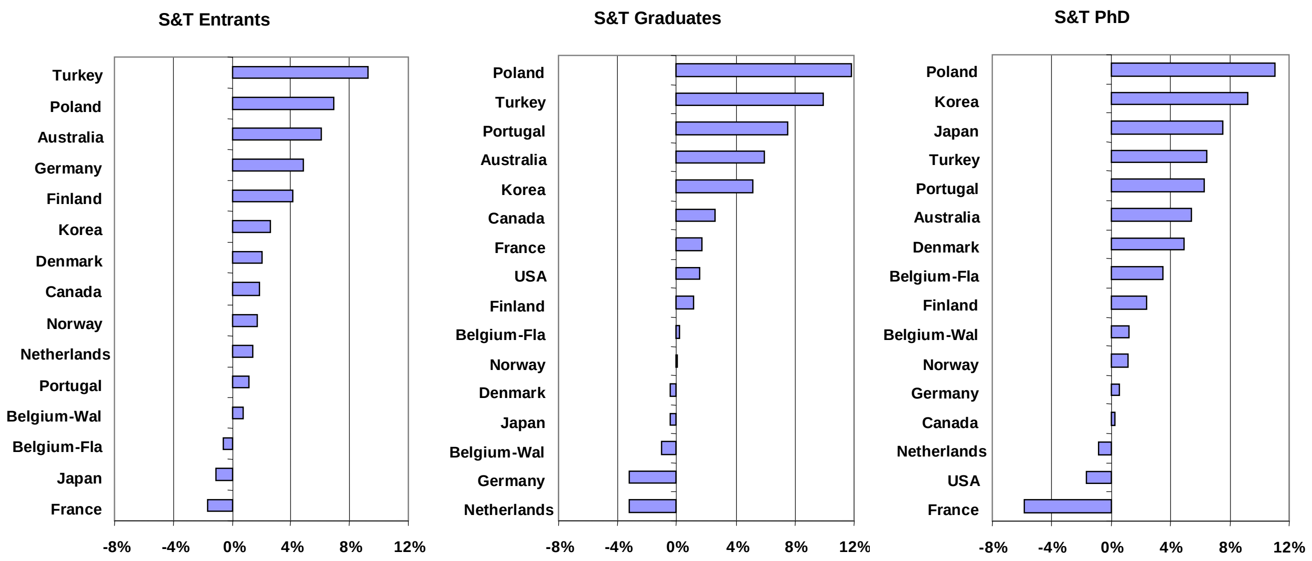


Figure 1. Number of S&T students - 1993-2003 average annual change (Mean normalized regression coefficient)

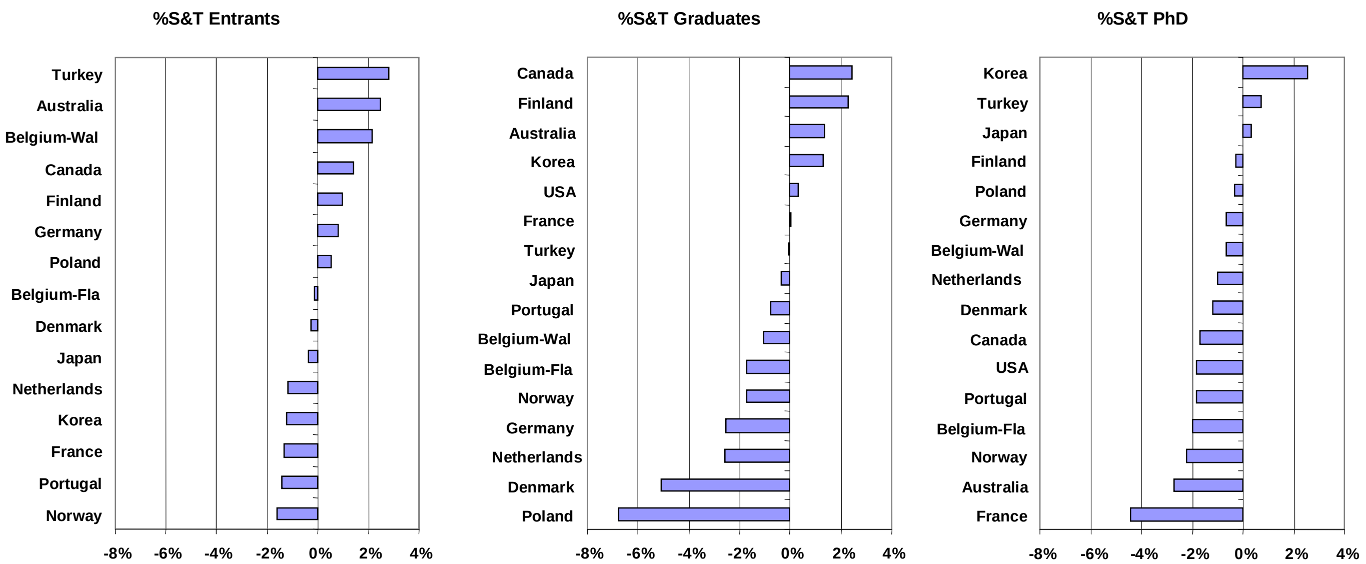


Figure 2. Percentage of S&T students - 1993-2003 average annual change (Mean normalized regression coefficient)

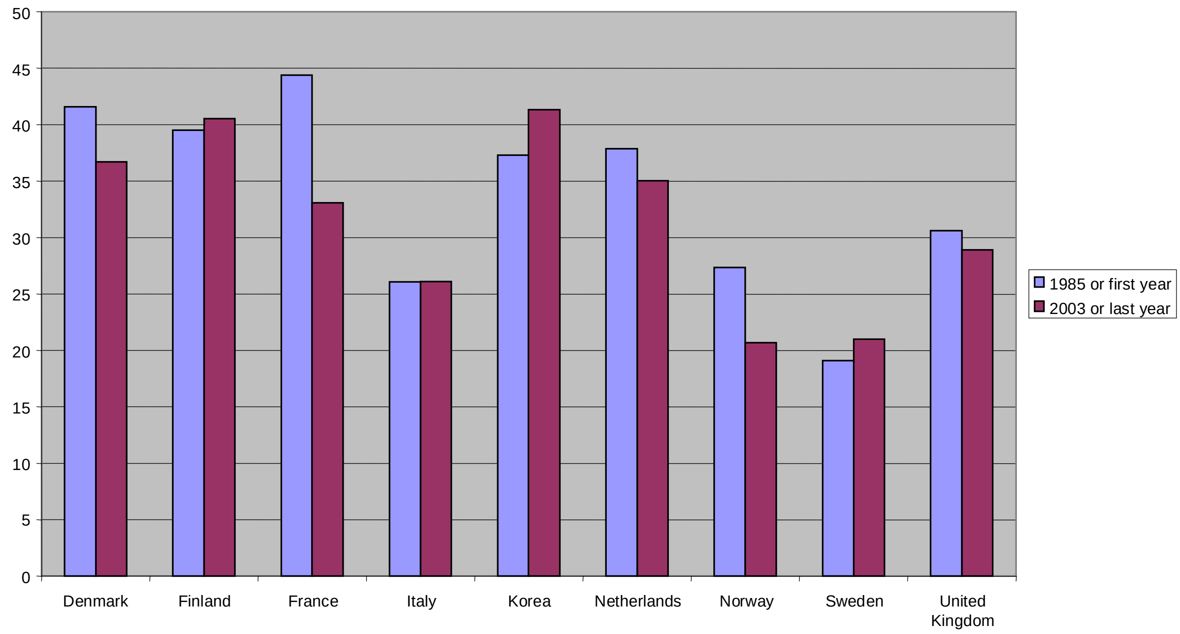
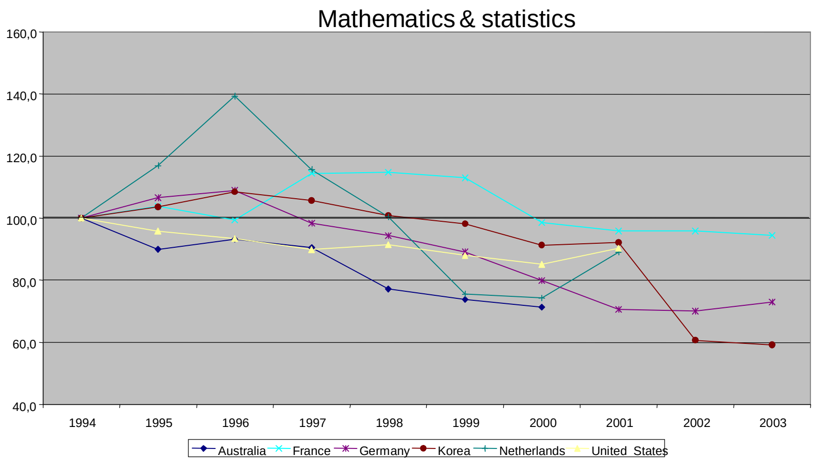


Figure 3. Percentage of upper secondary graduates with an S&T orientation



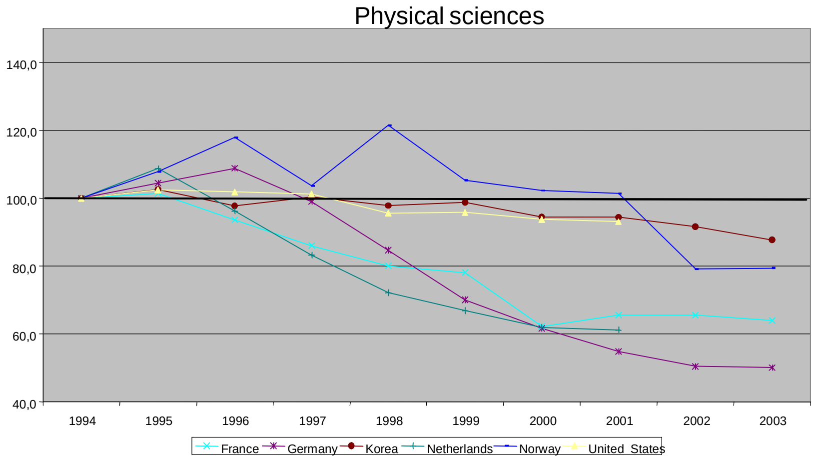


Figure 4. Total number of tertiary graduates in mathematics & statistics and physical sciences. Index 100: 1994

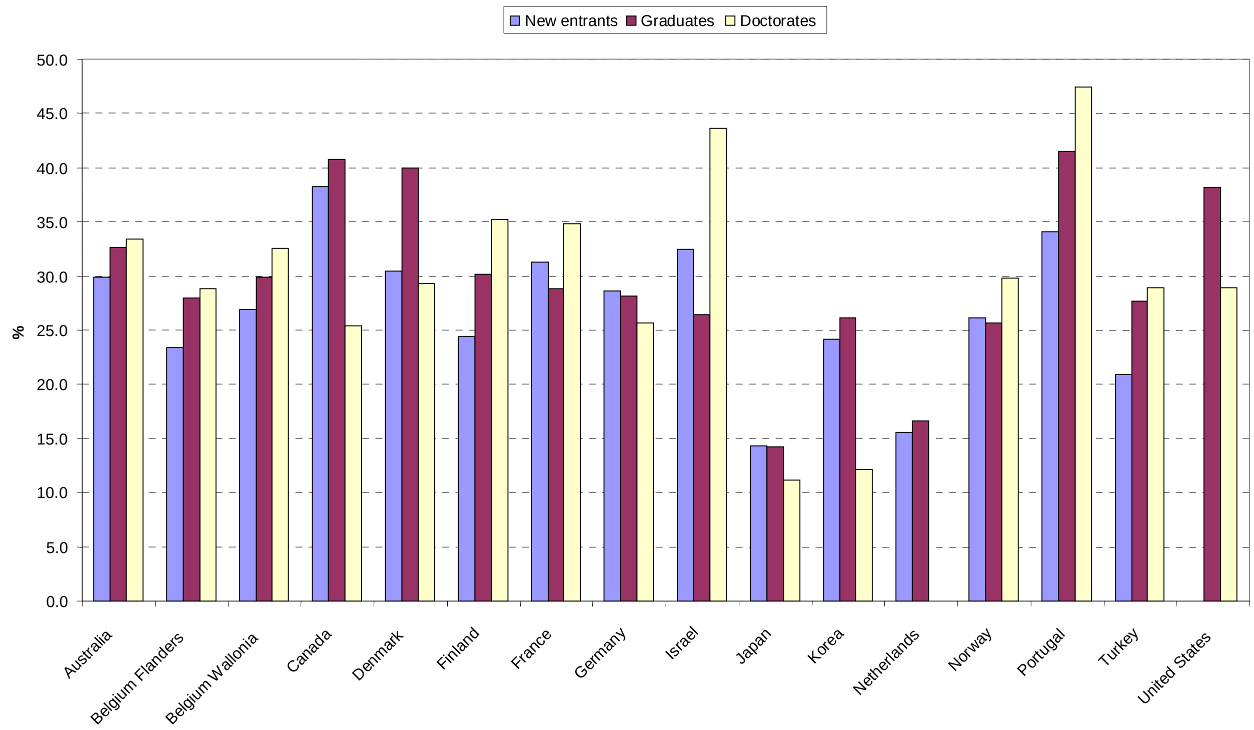


Figure 5. Percentage of female students in S&T disciplines - 2003 or latest year available

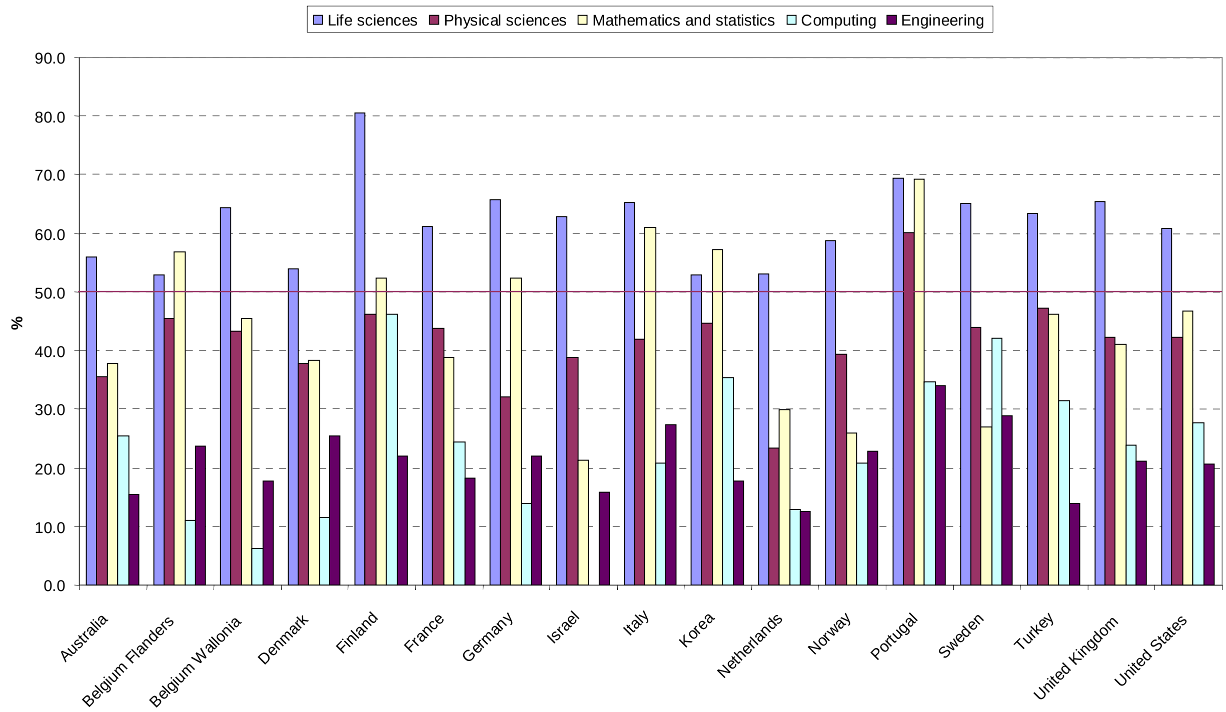


Figure 6. Percentage of female graduates by S&T disciplines - 2003 or latest year available

Appendix 2

List of participants to the Working Group

* Members of the Steering Committee, ** Chair of the Steering Committee

Chair	Sjoerd Wendelaar Bonga	Radboud University, Nijmegen, The Netherlands
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Belgium	Sabine Borrey*	Ministry of Flanders
	Henri Eisendrath	Free University Brussels
	Pierre Feyereisen*	Université Catholique de Louvain
Canada	William M. Coderre*	NSERC
Denmark	Nils O. Andersen*	Niels Bohr Institute, University of Copenhagen
	Kurt Johannesen	Ministry of Science, Technology and Innovation
European Commission	Stephen Parker	DG Research
	Ana Serrador	DG Education
Finland	Hannele Kurki	Academy of Finland
	Marja Montonen	National Board of Education
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