

The State of Technology Education: A European Commission Perspective

Wendy Dow and John Dakers, University of Glasgow, UK

Abstract

This paper arises out of a consultancy to the European Commission. The commission had identified a problem with recruitment to Mathematics, Science and Technology (MST) subjects and careers across Europe and wished to explore existing examples of good practice in the field. The paper describes the methodology used in two phases of the consultancy which set out to identify examples of good practice and highlights the problems encountered in doing this with particular reference to Technology education. The paper then describes examples of good practice in Technology education provided and discusses some of the common problems encountered by European countries in developing an effective system of technology education across all sectors of the education system.

Key words

Technology, education, pedagogy, collaboration

Background

The Lisbon European Council in March 2000 set the objective for the European Union to become the world's most dynamic knowledge based economy. It acknowledged that:

the European Union was confronted with a quantum shift resulting from globalisation and the knowledge-driven economy and agreed a strategic target for 2010: to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion. Stressing that these changes require not only a radical transformation of the European economy, but also a challenging programme for the modernisation of social welfare and education systems, the European Council at the same time asked the Education Council to "undertake a general reflection on the concrete objectives of education systems, focusing on common concerns while respecting national diversity, with a view to contributing to the Luxembourg and Cardiff processes and presenting a broader report to

the European Council in the Spring of 2001 (Council of the European Union: 5828/02, 2002: 5).

Thirteen objectives were subsequently agreed and priority was given to the implementation of three. These were objectives 1.2; developing skills for the knowledge economy: 1.3; ensuring access to ICT for everyone and 1.4; increasing recruitment to scientific and technical studies. An informal meeting of Ministers of Education and Ministers of Research held in Uppsala, Sweden in March 2001:

...underlined the importance of increasing recruitment to scientific and technological disciplines, including a general renewal of pedagogy and closer links with industry throughout the whole educational and training system (Council of the European Union: 5828/02, 2002: 21).

Science and technology education, along with mathematics was consequently identified by the Education Council as one of three priority areas for consideration as highlighted in the conclusions of the Stockholm European Council. This was in recognition of the view that scientific and technological advancement is not only fundamental for the development of a competitive knowledge society, but that specialised knowledge in these areas is increasingly an essential feature of both professional and private life. There was a consensus therefore that if Europe were to even maintain its position in the world there must be a concerted effort to ensure that more is done both to encourage young people to engage in the area and also to ensure the retention of those who have already embarked in related careers. An expert group, initially drawn from fifteen Member States was therefore established in September 2001 to identify key issues affecting uptake in the domain of mathematics, science and technology at all stages of the education system throughout Europe. This working group operated on the basis of the open method of coordination as defined in the conclusions of

The State of Technology Education: A European Commission Perspective

the European Lisbon Council. This method which is seen as “a fully decentralised approach using variable forms of partnerships and designed to help Member States to develop their own policies progressively (Council of the European Union: 5828/02, 2002. p10), is essentially concerned with the dissemination of good practice and with a greater convergence towards the achievement of the main objectives of the European Union as defined in the 2001 Council/ Commission Report on the objectives for education and training systems. The open method of coordination also involves establishing both quantitative and qualitative indicators against which success can be monitored, evaluated and subjected to peer review. This particular aspect was, however, the work of a separate Standing Group on Indicators and Benchmarks.

Although the working group was established in September 2001, it was not until phase 2 in March 2002 that a consultant to the European Commission was appointed. By this time membership of the group had been extended to include the associated countries of Malta and Cyprus, as well as various stakeholders and social partners who were active in the field. Significantly, however, the representation of participants in the working group demonstrated a very clear bias towards science, followed by mathematics and an extremely low representation supporting technology education. Not one of the stakeholder groups represented technology education. The appointment of the consultant who was an academic specialising in technology education may be interpreted as an attempt by the Commission to redress this imbalance.

Although key issues had been identified by the group in phase 1, it quickly became apparent in phase 2 that two major issues required to be addressed before an analysis of good practice could be carried out.

One major issue was the perceived need to make a clear distinction between science and technology. A crucial and elementary step in increasing recruitment into the fields of

mathematics, science and technology lies in establishing a clear definition of those terms. Whilst it can be considered a reasonable assumption that there is consensus regarding the meaning of the term mathematics, this consensus is not so apparent for definitions of science and technology.

In the context of the ‘Canberra Manual’ (1995) science is described as, at its widest, ‘...“knowledge” or “knowing”; in a narrower sense it is understood as being the kind of knowledge of which the various “sciences” like mathematics, physics or economics are examples...In ordinary English usage science is often synonymous with the natural sciences...’ (16). Technology on the other hand is described as ‘...“the application of knowledge”, and more narrowly dealing with tools and techniques for carrying out the plans to achieve desired objectives’ (16).

There exists in this context, a clear and distinct difference between science and technology. Moreover, the ‘Canberra Manual’ classifies six broad fields of science and technology, the first two being the natural sciences including mathematics and computer science programmes, followed by engineering and technology, which includes trade, craft and industrial programmes together with engineering programmes, architectural, transport and communications programmes. Other fields include medicine, agriculture and social sciences.

Once more a clear distinction is made between science and technology where technology has now been aligned to engineering. A significant and major barrier to recruitment into the science and technical studies domain is thus a common misunderstanding of the terminology, ‘science’ and ‘technology’. The documents used by the Commission made use of the multifarious terms ‘increasing the recruitment to science and technical studies’, ‘scientific and technological development’, ‘science and maths’, ‘science and technology’ and ‘scientific disciplines’. It is not clear if these are seen to have different meanings or if they are fundamentally the same.

The State of Technology Education: A European Commission Perspective

Barlex and Pitt (2000), explored the relationship between science and technology in English secondary schools. Their research highlights the distinctive natures of science and technology and clearly identifies their unique and distinguishing features. This distinction between science and technology is supported by many authors such as Kline (1985); Staudenmaier (1985); Black and Harrison (1992); Layton (1993); Benne and Birnbaum (1978); Gardner (1994) and Harlen (2000).

In order to make a clear distinction, therefore, the working group agreed to exclude from the definition of "science" all scientific fields other than the natural sciences, and to classify technology as relating to those disciplines more closely related to engineering. In terms of school based subjects, science incorporated physics, chemistry and biology and the technology curriculum was described as the design process which incorporates an understanding of the tools and techniques required in order to carry out plans which will achieve the desired objectives. In addition, it was recognised that the importance of their impact on a given culture should be an important factor permeating all aspects of these curricular areas.

The second major issue was the need to develop a coherent framework within which initiatives from across Europe could be evaluated and compared. An initial framework was subsequently drawn up outlining what had inspired the initiative, or which particular problems it was designed to address; the aims and objectives along with a detailed account of how the examples of good practice met the aims and objectives; the target groups; the key partners and activities and working methods involved; sub-themes covered and the nature of financial support provided for initiation or development. Self evaluation of the initiative was invited by means of a rating of its perceived impact from 1-5 (with 5 being the highest rating) Respondents were also asked to identify any areas which they felt required further development and to state whether the initiative would be available for peer review.

From the initial analysis of the data received by these means, the intention was to provide an overview or map of good practice across Europe.

The Problems

The initial stage of the analysis highlighted a number of problems. Two pertained to the composition of the working group. As this comprised a mixture of representatives of ministries of education, academics and interested stakeholders, it was clear that detailed knowledge about both the existence of initiatives and their effectiveness in increasing recruitment to the subjects was mixed. It was clear in some cases, for example, that there were successful initiatives in place, which the particular representatives were unaware of. This problem was moreover compounded by the decentralised nature of the education system in some countries where projects were clearly being instigated at a local, or even school level. In these cases it is clearly difficult for central administrations to have a complete overview of all the existing initiatives in the field.

The second issue relating to group composition lay in the imbalance in numbers between representatives and academics who had a particular expertise and interest in science education and those whose interest and expertise lay in the area of technology education. This imbalance, which favoured the former group, had indeed accounted for the initial difficulties of the group in making a clear distinction between science and technology and it was through an emphasis on the importance of making this distinction that the appointment of the consultant may have been made.

Another general problem involved a difficulty in evaluating the effectiveness of initiatives from the rating scale. A number of issues contributed to this. One was the largely subjective nature of evaluation. In the majority of cases there had been no external evaluation carried out. In many cases this was because initiatives were of relatively recent inception and any evaluation was, as a consequence, limited in scope. It was apparent, moreover,

The State of Technology Education: A European Commission Perspective

that initiatives, particularly at primary and secondary level would require to have longitudinal evaluation before their real effectiveness in increasing recruitment to careers relating to science and technology could be determined. Added to this, there are the problems traditionally associated with the evaluation of educational initiatives. The novelty aspect of new materials and programmes of work, for example, can often in themselves result in initial gains in interest and attainment, which are not, however, maintained over time. Within pupil characteristics, within teacher characteristics and the complex interaction, which occurs within the context of busy classrooms are also factors which can promote or militate against success. Socio-economic and cultural factors add further complexity to the process. For these reasons, it is clear that any initial indication of success requires to be treated with caution and to be subjected to more rigorous evaluation over a considerable period of time.

Closely related to the problem of establishing reasons for the success of any initiative is the problem of identifying what exactly good practice is. As Black and Atkin (1996) suggest, "there is no single best way to achieve innovation or best practice" and that what constitutes as good practice in one country may be very different from good practice in another, or as Krainer (2002) suggests:

There is no "best practice" which might be defined by an external authority. For each learning and teaching, different approaches to "good practice" exist. Innovations are planned steps towards good practice (9).

A final problem related to the varied use of the framework. Whilst some respondents followed the suggested framework exactly, others submitted information in narrative or in idiosyncratic form. There was also a wide variation in the level of detail provided from extended to one word answers. There was an attempt to address these problems by asking individual respondents for additional information where this was deemed necessary.

Preliminary Analysis

A total of 40 examples of good practice from twenty European countries and other stakeholders was provided and these were analysed in the first phase. Although the areas of concern and aims and objectives varied, the major themes which emerged indicated that there was a concern about a lack of interest in mathematics, science and technology education in general and that specific concerns related to effective pre-service and in-service teacher education, issues of pupil equity, with particular emphasis on high and low achievers and gender, and the development of appropriate didactics, resources and career information.

As the examples of good practice provided demonstrated considerable variety in terms of scope and scale, the decision was made to include in the final analysis only those examples which were policy at national level and which had clear indications regarding the success (or otherwise of the project) This immediately placed a severe constraint on the number of initiatives which could be considered as examples of good practice.

Initiatives were arranged according to whether their main focus was on mathematics, science or technology education and these were subdivided according to their location in primary, secondary or tertiary education. There were also sections, which included examples relating specifically to teacher education, gender and examples of systemic reform. For the purposes of this paper, only those examples relating to technology education will be considered.

Technology education initiatives
It was clear from the initial analysis that initiatives relating to technology were in a minority compared to those relating to science. Whereas a total of twenty-nine initiatives relating to science across all sectors of the education system were provided, only sixteen in total related to technology. This imbalance became even more marked when the constraints described above were imposed.

The State of Technology Education: A European Commission Perspective

From the five countries that provided examples of good practice in technology education in primary schools, only three, from Belgium (Flemish Community), Malta and the Netherlands were examples of national policy directed at the primary curriculum. Although there was a recognition that evidence of success is hard to determine and methodologically problematic, all had some attempt at evaluation although this was of necessity at an early stage. At secondary level only four examples focusing specifically on good practice in technology education were provided, with three of these coming from England and the fourth from Slovenia. Only two of the English projects, however, could be included as examples of national policy. One further example of good practice from Norway was applicable at both primary and secondary level. At tertiary level only the Netherlands provided an example of courses specifically developed in partnership with industry, schools and universities in the areas of Human Engineering and Human Technology which had been designed to attract more students, and specifically girls, into the area. Although two other tertiary education initiatives from Austria also specifically addressed the issue of gender, in these, as in many other initiatives, science and technology tended to be treated as one and the same thing.

Teacher confidence

From the analysis of technology initiatives, some generic issues arose. The importance of developing the interest of pupils in the area of technology from an early age was highlighted as an important issue, although this was clearly not reflected in the number of initiatives provided in this area. An important factor, which may at least partly account for the low number of initiatives at this stage involves levels of teacher confidence.

Research carried out in England to determine the confidence levels of primary teachers in the delivery of science (Harlen, 1996, Stables, 1997) for example demonstrated problems in this area by identifying a high number of primary teachers who had no background in science

(65%). An investigation of confidence levels of both science and technology (Harlen and Holroyd, 1996) concluded, moreover that, in general, primary teachers had a low level of confidence in teaching these areas. Similar studies carried out in Scotland (Dakers, 2001; Dakers and Dow, 2004) indicated similar problems with teacher confidence relating specifically to the teaching of technology.

That this is a problem in many European countries is further evident from the initiatives relating specifically to teacher education courses, where a particular concern expressed was the need to increase confidence of teachers at all levels, but most particularly at the primary stages. New programmes for teachers, part time studies for existing teachers, support for teachers in the development of resources and methodologies through short courses or internet networks were some examples of attempts to tackle this particular issue in a number of countries.

The place of technology in the curriculum In the case of Belgium (Flemish Community) and Malta, technology education was treated as a discrete subject within the primary curriculum. It is possible, however for a more holistic and integrated approach to the curriculum to be adopted at primary level. This was the approach taken by the Dutch project, which also, interestingly, addressed the important problem of teacher confidence. The Axis Platform project developed in the Netherlands for integrating technology into the primary curriculum is an initiative, which involves embedding both technology and science into the curriculum of primary schools. The materials and methods consist of implementation strategies, curriculum programmes in which technology is integrated, technology lessons, physical tools and instruments and service centres in teacher training institutes. By these means, technology is integrated with the main curriculum areas of literacy and numeracy and used as an instrument to facilitate learning across the entire primary curriculum. Building a construction is, for example, regarded as a natural way of acquiring mathematical principles as well as an

The State of Technology Education: A European Commission Perspective

effective means of acquiring skills such as planning and cooperation. Thus a holistic approach, which takes into account the development of integrated skills is achieved.

Transition

The enthusiasm demonstrated by pupils in primary school for subjects like technology can, however, be difficult to maintain after transition to the secondary sector. An important aspect of this is problems associated with the transition process itself.

Several factors affecting the success of transition from primary to secondary school in relation to curricular continuity have traditionally been identified. These include: the existence of effective liaison procedures; a knowledge and understanding on the part of both sectors about the respective courses taught, programmes of work and teaching methods adopted; a willingness on the part of secondary teachers to value the work done in primary schools and to trust the primary teachers' judgements in terms of assessment, along with a willingness to use the information to provide a starting point appropriate for each individual pupil (Nicholls and Gardner, 1999). Secondary teachers must also have commitment to a curriculum, which builds upon the knowledge, understanding and skills appropriate to their subject which pupils have already acquired.

Whilst these factors are clearly important in all areas of the curriculum, it is perhaps in the area of the technology curriculum that the least progress in affecting a successful transition has been made.

The example of good practice provided by Norway was specifically designed to bridge the transition from the primary to secondary sector, a transition, which is traditionally regarded as a barrier to maintaining interest and achievement. In this case attention has been paid to achieving a continuous programme of technology and design, which bridged the gap between primary and the lower stages of secondary.

Pedagogy

Other countries have attempted to address the problem of diminishing interest at the secondary stages by attempts to introduce changes in the methodologies or didactics employed. There is a growing recognition that in order to learn effectively, children must be actively involved in the learning process. Effective learning, moreover, is increasingly regarded as an essentially socially mediated process. Learning is fundamentally constituted through interactions and relationships in a given sociocultural system (Cole, 1996; Engestrom et al, 1999; Lave, 1993; Lemke, 1997; Matusov, 1998; Rogoff, 1990; Vygotsky, 1978; Walkerdine, 1997; Wenger, 1998). This system comprises, at the micro level, a variety of particular cultural identities situated in a particular environment, whether natural, social or artifactual, where a community of practice, and thus learning, is constituted and where "[p]ractice is not conceived of as independent of learning" (Barab & Duffy, 2000: 26).

There was a general consensus, therefore that both technology and science education, should be moving away from the transmission model and the acquisition of facts towards a system "more concerned with interpretation and understanding than in the achievement of factual knowledge or skilled performance" (Olsen and Bruner, 1996:19) There is, in all examples of good practice, therefore a particular emphasis on the type of pedagogy which will develop higher order thinking skills such as problem solving, research skills and meta cognition as well as producing motivated and autonomous learners. In addition the importance of setting learning within authentic contexts, which are meaningful to pupils was clearly recognised. There is evidence that both specific skills and generic skills are best acquired within authentic practice contexts. Relating technological concepts to the world and making connections between subjects and contemporary society helps to make the subject areas more accessible. Thus in the example of good practice in primary technology from Belgium (Flemish Community) an attempt was being made to increase both motivation and

The State of Technology Education: A European Commission Perspective

effective learning by means of a hands-on approach using original educational material within real life contexts, These included activities such as working with real chips in different stages of fabrication, the disassembly of digital telephones and the building of electronic circuits. Practical work of this type was further backed up with a variety of resources such CD ROMS, videos and photographs. Crucially, support for teachers had also been incorporated by the provision of written guidance to assist with the implementation of practical work and demonstrations during which teachers took on the role of pupils.

In addition to real life contextualised learning and practical skill development being the guiding principle of the Norwegian initiative, the development of an understanding of the impact of on society technology formed an important aspect of this initiative.

In the English initiatives in secondary technology education, there was a similar focus on increasing motivation through the adoption of practical activities set within authentic learning contexts. In the "Young Foresight" initiative for example, important skills of communication and collaboration are developed as pupils work in groups to design, (but interestingly, not to make) products and services for the future. By this means creativity is encouraged by enabling pupils to concentrate purely on the design process, free from the constraints of having to produce an artefact using pre- existing materials and technologies. Context is provided as pupils are encouraged to take account of the likely priorities of a future society, the needs and wants of users and the influences of existing or developing markets. Presentation skills are also a feature as groups present and justify their particular designs to peers, teachers, mentors and other audiences.

The importance of real life contexts has been addressed more simply in Slovenia through the incorporation of a Technical Gymnasium into the general secondary education framework

leading to university studies. This has involved the development of an optional curriculum comprising mechanical engineering, civil engineering, computing engineering and biotechnology with materials technology planned for the future.

Collaboration with outside agencies

As part of the development of authentic and meaningful learning contexts, collaboration between schools, universities and industry was seen as an important feature of good practice. The crucial importance of this was reflected in the fact that virtually all initiatives in all three areas of mathematics, science and technology had some form of link with industry and other relevant institutions. Although these were at various stages of development, in some instances they were well formed and involved funding as well as support and advice. All the initiatives in technology were supported to some extent by a mixture of private and government funding. In the case of the Netherlands, the fact that five different industries were willing to adopt a long term view and to collaborate with schools and the ministry of education to support an initiative introduced at the primary stage of education was regarded as particularly significant.

"That the business community on a higher level is now funding the programme in primary education, which is at least ten years away from any benefits that they might get, is quite unique (sic)"

This mutual benefit to both schools and education is further exemplified in the English "Young Foresight" initiative where industry will clearly benefit from the development of pupils as designers.

Despite these advantages, however, beyond the issue of funding, there was no clear indication at national level of how partnerships between schools and industry were being developed in any coherent way. It was clear, moreover that initiatives involving industry were often of a voluntary nature. This finding is similar to the findings of research carried out into school

The State of Technology Education: A European Commission Perspective

industry links in the United States by Black and Atkin (1996). The strongest links in fact appeared to be, not with industry, but with Higher Education Institutes where although outcome had been varied, some success appeared to have been made in increasing teacher expertise and confidence through the development of materials at primary school level and at secondary level in assisting teachers to improve and update content knowledge, to introduce new didactics based on current theories of learning, to make the important links between theory and practice and to engage in the type of action research which would help their development as reflective practitioners.

Second phase

Because of the difficulty of acquiring a clear picture during the first phase of the work described above, the second phase involved sending out a questionnaire to all participants based on a set of five recommendations, which had emerged from the first phase of the work. These were: that the teaching of maths, science and technology should be an entitlement for all from an early age; that more effective and attractive teaching methods should be introduced at primary and secondary level; that improvements in courses for teachers at pre service and in-service level should be provided; that initiatives should address gender and special needs issues; and that the development of partnerships between the different education sectors and industry should play a central role.

The intention of collecting the information based on these recommendations was two-fold. The first intention was to obtain a "map" or overview of implemented (or at this stage planned) measures at national level in relation to the recommendations. The reason for this was the identification of areas for development and to enable future monitoring of progress. The second intention was to gain a more detailed picture of initiatives which were directly seen to be addressing the areas of recommendation identified. Twenty-five questionnaires were returned and analysed in this phase.

Some important findings emerged from this stage of the analysis which have particular implications for technology education.

Entitlement

In terms of entitlement, from the information provided, it would appear that although the entitlement to study mathematics and science from an early age is generally well recognised, through the mandatory inclusion of these subjects in the curriculum from (in most cases) ISCED (International Standard Classification of Education) 1, the provision of technology appears to be regarded as less of a priority at this stage. At ISCED 2 a similar picture appeared to emerge. Although mathematics and science are again mandatory in almost all countries at the lower secondary stage, fewer countries have similar provision for technology. Technology is more likely to be offered at the upper stages and, in countries where there is separate provision of vocational and academic education, to form part of the vocational curriculum.

Pedagogy

Although pedagogy had been identified as an important area for development throughout, and although some initiatives analysed in the first phase were clearly attempting to address this, it became apparent that there was a clear recognition that such changes are not necessarily easy to implement. Only a small minority of countries did not identify challenges or barriers in this respect. Of those countries who did identify barriers, the majority identified difficulty in persuading teachers to discard the more traditional text-based, theoretical methods and to adopt methods more appropriate for the practical, authentic, social constructivist methods identified as necessary for increasing both motivation and achievement. Thus although the importance of a change in pedagogy has been generally recognised at policy level, it is at practitioner level that problems are perceived to persist. A number of respondents attempted to identify reasons for this reluctance to change. The scepticism of teachers to the "top down" model of reform, the deterioration of working conditions, cultural influences, lack of

The State of Technology Education: A European Commission Perspective

incentives for professional development, the lack of appropriate support in the form of pre service and in service education and lack the necessary time and resources to carry out work of this nature were among the possible reasons raised. There was a clear recognition that, in order for new didactics to be introduced, teachers will require, not only high quality training but also the time necessary to assimilate and adopt new teaching methods. It may also take time to convince some teachers that the adoption of new methods will in fact result in more motivated and competent students in the field.

A number of countries appeared to be attempting to support teachers through the development of resource centres. These have been set up in collaboration with Higher Education Institutes to offer help and support to teachers in the development of appropriate resource and didactics. Again, however, the focus appeared to be strongly on science. Thus although, for example, a resource centre specifically devoted to technology education does in fact exist in Sweden, this was not included in the information provided by the representative.

Collaboration with outside agencies

Although all countries indicated that they had some type of initiative involving some form of partnership between schools and Higher Education Institutes in place, these were generally fairly small scale, ranging from single day events such as fairs and competitions, opportunities for high aptitude pupils to attend university classes, mentoring schemes involving university students partnering school pupils or academics assisting pupils and teachers in schools in becoming involved in research.

In some cases there was also some involvement with industry although this was mentioned less frequently. Once again, moreover, when initiatives relating specifically to technology were considered, these were found to constitute the smallest number with only France providing an example of national and local partnership with industry and technical and vocational schools.

Equity

The highest level of provision in this area was for high achieving pupils. There was, again, however, a much greater focus on mathematics and science in this area with only the UK and Finland offering specialist schools for pupils with a special aptitude for and interest in technology. In other countries, technology was more likely to be regarded as suitable for pupils in the vocational curriculum

Although a need to address the gender imbalance was identified as an important area for development, not all countries perceived the gender issue to be a particular problem. The respondents from Bulgaria, Cyprus, the Czech Republic, Finland, Slovakia and Slovenia all either felt that the gender imbalance was not an issue, or at least not a priority. This was again particularly the case where mathematics and science was concerned. Even in those countries where a gender balance was not regarded as a problem, however, there was clearly a marked imbalance when technology subjects were taken into consideration. Thus in Finland, for example, whereas 52% of Masters degrees and 43% of Doctorates in mathematics and science are taken by women, this drops to 24% and 21% respectively for Masters and Doctorate degrees in technology. A similar picture emerges in Slovakia and Slovenia where there is a 23% uptake for civil engineering and a 5% uptake electro-engineering by females in the first country and a pronounced gender imbalance in engineering at secondary and tertiary levels of education in the second.

Although a number of countries are attempting to address issues of gender in general, through policies designed to address equality of opportunity, measures designed specifically to increase recruitment in the area of technology education tend to be scarce and small scale. At secondary school level, for example Sweden has introduced a technical programme designed specifically to appeal to girls, whilst in the Netherlands there has been an attempt to address the problem by means of extra curricular initiatives aimed at raising the interest of girls in technology subjects. At

The State of Technology Education: A European Commission Perspective

tertiary level, Norway has attempted to address the problem through the provision of a special quota of places for female students in Computer Technology at the University of Science and Technology whilst the LUMA project in Finland works in collaboration with industry in an attempt to encourage women to enter careers in the technology field. Similar initiatives to encourage females to adopt careers in engineering related subjects are in operation on a relatively small scale in Germany in the form of mentoring schemes in which successful female engineering students act as role models to school pupils and on a larger scale in Ireland where ministry support has been provided for a comprehensive system, which uses CD profiles to support secondary school staff in promoting careers for women in engineering.

Conclusions

It seems clear that, from the perspective of the particular experts involved in the collation of examples of good practice that technology education played a secondary role to science. Although there is evidence from other sources of important initiatives specifically relating to technology occurring in a number of countries, information about these was not being provided to the working group. There are several possible reasons for this. One is clearly the composition of the expert group. In only one case did the ministry representative have a remit specifically directed towards technology education. Another is the way in which knowledge about initiatives is disseminated within countries. In countries with decentralised education systems, for example it is possible that ministry representatives lacked knowledge about interesting initiatives being implemented at local level. The examples of good practice identified were therefore to a large degree dependent on how information about initiatives was sourced. This was evident for example in Sweden where information and a subsequent case study visit focused on the provision for science education although similar provision for technology education did in fact exist.

Another important issue concerns the apparent status of technology education in the curriculum. Whereas mathematics and, to a slightly lesser degree, science is generally considered to be an entitlement for all from an early age, the position of technology education, even in the secondary curriculum, is much less clear. This may be related to the fact that traditionally in many countries, technology education has lacked a clear identity or has been rooted in an industrial model, which is lacking in relevance for the 21st Century. Thus there is a tendency to continue to regard it as suitable for only less academic pupils. Science, on the other hand, with its more traditional academic roots, appears to have a more easily identifiable place for all within the education system. There is a clear need therefore for the role of technology education and for the need for technological knowledge and literacy for all citizens to become a central part of the debate.

Pedagogy was considered a central issue in the promotion and retention of interest. Changing traditional practice is, however, a complex issue which seems likely to involve radical and systemic change. More effective pre service and in-service courses will require to be developed and resources and support for teachers provided at all levels of the education system. Sufficient time will also have to be made available for more authentic and meaningful learning experiences within the school day. Assessment systems, which encourage a transmission approach and surface learning of facts will require to be changed to take account of process rather than product. Bottom-up processes, which encourage teachers to debate and be actively involved in change are more likely to succeed in this than top-down policy measures by which change is dictated. Stronger, closer and more formal links with industry may be an important factor in encouraging this change.

Although the sharing of good practice is clearly a benefit in helping countries to develop policy, cultural differences will need to be addressed. What works in increasing interest and achievement in one country may not work in

The State of Technology Education: A European Commission Perspective

another. Whereas in some countries, competition is regarded as an important means of motivating pupils, others find this counterproductive and elitist. In these countries the focus is on collaboration and team-work. In the light of this, it will be important to resist any kind of uniform European-wide policy. Whilst any apparent success of projects is clearly a cause for celebration, caution must be exercised regarding making claims for long term and sustained success. Projects, which are currently in the early stages of initiation will require long term, rigorous evaluation before a final analysis of their effectiveness can confidently be determined and the need for increased recruitment fully addressed.

wdow@educ.gla.ac.uk
jdakers@educ.gla.ac.uk

References

- Barab, S. A. & Duffy, T. M. (2000). From Practice Fields to Communities of Practice. In: David H Jonassen & Susan M Land. (Eds.) *Theoretical Foundations of Learning Environments*. Lawrence Erlbaum Associates. New Jersey.
- Barlex, D. and Pitt, J. (2000) *Interaction. The Relationship Between Science and Design and Technology in the Secondary School Curriculum*. Engineering Council. London.
- Bennie, K. and Birbaum, M. (1978) *Teaching and Learning about Science and Social Policy*. Boulder CO, USA: ERIC Clearinghouse for Social Studies/Social Science Education/Social Science Education Consortium.
- Black, P., Atkin, J. M. (1996). *Changing the Subject: Innovations in Science, Mathematics and Technology Education*. Routledge. London.
- Black, P. and Harrison, G. (1992) in McCormick, R. (Eds) *Teaching and Learning Technology*. Wokingham: Addison-Wesley Publishing Company, in association with the Open University, Milton Keynes.
- Canberra Manual. (1995). *The Measurement of Scientific and Technological Activities*. Manual on the Measurement of Human Resources Devoted to S&T. 'Canberra Manual'. OECD and ECSC-EC-EAEC, Brussels. Luxembourg. (1995) www.oecd.org/dataoecd/34/0/2096025.pdf (accessed March 2nd 2005)
- Cole, M. (1996). *Cultural Psychology: A Once and Future Discipline*. Cambridge, MA: The Bellknapp Press of Harvard University Press.
- Council of the European Union (2002). *Detailed programme on the follow-up of the objectives of education and training systems in Europe*. 5828/02, 2002.
- Dakers, J. (2001). Primary Teachers Confidence in Delivering Technology Education. In: (Eds) Benson, C., Martin, M., Till, W., *Third International Primary Design and Technology Conference Proceedings*. Birmingham. CRIPT: 50-54.
- Dakers, J., Dow, W. (2004). The problem with Transition in Technology Education: A Scottish Perspective. *The Journal of Design and Technology Education*. 9:2 116-124
- Engeström Y, Miettinen R and Punamäki R (1999) *Perspectives on activity theory*. New York/Cambridge: Cambridge University Press.
- Krainer, K., (2002). *Innovations in Mathematics, Science and Technology Teaching (IMST2) Initial Outcome of a Nationwide Initiative for Upper Secondary Schools in Austria*
- Gardner, P. (1994) Representations of the relationship between science and technology in the curriculum. *Studies in Science Education* 24:29-47.
- Harlen, W. (1996). Primary Teachers' Understanding in Science and its impact in the classroom. Paper presented at the *British Educational Research Association's Annual Conference*, Lancaster, September 1996. Scottish Council for Research into Education.

The State of Technology Education: A European Commission Perspective

Harlen, W., Holroyd, C. (1996). Primary Teachers' Understanding of Concepts in Science and Technology. *Interchange* No. 34. Research and Intelligence Unit.

Harlen, W. (2000) *Teaching, Learning and Assessing Science* 5-12. Paul Chapman Publishing. London

Kline, S.J. (1985) What is technology? *Bulletin of Science, Technology and Society*. 5 (3):215-18

Layton, D. (1993) *Technology's Challenge to Science Education – Cathedral, Quarry or Company Store*. Buckingham and Philadelphia: Open University Press.

Lave, J. (1993). Situated Learning in Communities of Practice. In: L. B. Resnick, J. M. Levine, S. D. Teasley. (Eds.) *Perspectives on socially shared cognition*. American Psychological Association. Washington 17-36.

Lemke, J. (1997). Cognition, Context and Learning. A social semiotic perspective. In: D. Krishna & J. A. Whitson (Eds.) *Situated cognition, social, semiotic, and psychological perspectives*. Lawrence Erlbaum Associates. New Jersey 37-56.

Matusov, E. (1998). When solo activity is not privileged: participation and internalisation models of development. *Human Development*. Karger. 41:326-349

Nicholls, G., Gardner, J. (1999). *Pupils in Transition*. Routledge. London.

Olson . D. R., & Bruner, J. S. (1996). Folk Psychology and Folk Pedagogy. In Olson, O.R., & Torrance, N. (Ed), *The Handbook of Education and Human Development*. Blackwell USA and UK.

Rogoff, B. (1990). *Apprenticeships in Learning: Cognitive Development in Social Context*. Oxford University Press. New York.

Stables, K. (1997). Critical Issues to consider

when Introducing Technology Education into the Curriculum of Young Learners. *Journal of Technology Education*. 8,2.

Staudenmaier, J. (1985) *Technology's Storytellers: Reweaving the Human Fabric*. Cambridge, Mass., USA and London. UK: Society for the History of Technology and the M.I.T. Press.

Vygotsky, L. S. (1978). *Mind in Society. The Development of Higher Psychological Processes*. Harvard University Press. Massachusetts.

Walkerdine, V. (1997). Redefining the subject in situated cognition theory. In: D. Krishna & J. A. Whitson (Eds.) *Situated cognition, social, semiotic, and psychological perspectives*. Lawrence Erlbaum Associates. New Jersey 57-70.

Wenger, E. (1998). *Communities of Practice: Learning Meaning and Identity*. Cambridge University Press. Cambridge.