Approaches and models in technology teacher education: an overview

This research will help you to think about:

- the role and function of teacher education in technology
- the relationships between the UK and a range of overseas nations
- the variety of skills and understandings that are needed by teachers
- the dependency of these skills on the particular conception of technology used in the country.

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Abstract

In this paper, I give an overview of the different models and approaches to technology teacher education. Many of the issues which shape the requirements for the professional development of teachers are common to the different teacher education structures which exist, and the need to improve the quality and quantity of technology teachers is shared by all countries. By standing apart from any one country's programme, perhaps novel solutions to common problems will present themselves. I present here a framework for analysis which may be applied to a range of courses, both pre-service and INSET, and consider both new and traditional approaches to the education of technology teachers.

Introduction

There is no doubt that many concerns about the current position regarding the education and training of technology teachers are shared by teachers, teacher educators and politicians in many countries. For example, a colleague from the USA recently sent me the following e-mail:

"Technology Teacher Education programs at the University level are not graduating enough teachers to meet the current demand in public schools and do not have enough students in their programs to meet the immediate future demand.

Technology Teacher Education lags behind the demand for many reasons:

(1) cutbacks in higher education

(2) people don't want to go into the teaching profession

(3) salaries have not kept up when compared to other industrial jobs

(4) teaching is not held in high status by the general public." (E.N. Israel December 4 1995)

There are other common concerns of a professional nature. Technology is a new subject and the aims and purposes of its inclusion in the curriculum of all pupils are often still unclear. This lack of clarity causes confusion amongst the different teachers who currently teach the subject. They are still unsure of the relationship of school technology to manual subjects of the past, and also to science, mathematics and other subjects in the current curriculum. This applies to student teachers too. From a clearer rationale for the subject comes a sense of purpose and direction for teachers. More appropriate pedagogy and better classroom resources follow on from this.

As the history of the subject is so short, there are difficult challenges for technology subject updating; raising awareness of new teaching strategies; and the preparation of novel curriculum resources. However, it may be possible to be innovative in the mode of provision of training and retraining schemes to help to tackle these common difficulties. I address that issue later.

To frame the analysis, I consider three principal concerns in technology teacher education:

- The **rationale** for technology for all pupils (briefly);
- The different **curriculum emphases** for both the school and the teacher-education curricula.
- The **modes of presentation** of teacher education courses which address both these curriculum emphases, and other concerns following from policy.

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A rationale for technology for all

In any consideration of the preparation of teachers for their role in the classroom (or workshop) one must naturally consider the nature of the school technology curriculum for which they are being prepared. The nature of school technology within a particular educational system has a rationale firstly in the purpose and aims different 'players' see for the subject, and secondly in the life history of those subject teachers who are charged with developing the curriculum in the schools.

McCormick (1990 p 5) proposes four general purposes for the creation of technology education:

- its intrinsic value

He argues that two important aspects of learning which are a challenge to the intellect flow naturally from school technology; first the solving of real problems and the reflective thinking such problem-solving promotes, and second the synthesis of thought consequent on that process because real life does not respect traditional subject boundaries.

- education for citizenship

All people should be aware of an important part of our culture. Lawton, in an analysis of cultural variables, noted "Specialisation is inevitable, but schools have a function not simply to select for specialisation, but also to enable the young to have a general technological understanding despite the need for specialisation" (Lawton, 1983 p 16). This is a plea for the inclusion in the curriculum of an aspect of life which has a direct impact on us all, not just 'experts', and for which we as citizens should be empowered to express an informed opinion.

- education for capability

There is a need to educate people who can 'do' as well as 'know'. Not one or the other but both. The tradition of liberal-humanism in schools has for so long denigrated the practical in favour of the academic. This is true in many parts of the world. In Colombia, Peña (1992 p 147) notes: "At one end of the spectrum practical knowledge tended to be dismissed as "instrumental" while, at the other end, science and mathematics were frequently seen as mere and useless theory." And "in Kenya and many countries of Africa, there has never been a strong relationship between the subject learnt and its usefulness in the real-life situation outside the school. Most subjects are taught in a decontextualised form..." (Kapiyo, 1992, p 120). Technology is an excellent curriculum vehicle for promoting planning, personal organisation and working with others in order to 'make things happen'. Some argue that the problem-solving nature of technology education alone makes the case for technology-for-all. For the USA in particular, the general applicability of technological problem-solving and the 'design-process' have been used as powerful educational and political arguments to move the subject away from an industrial-arts/craft focus for only a few, to a general subject for all pupils. Some have seen this universal problem-solving as a myth and question the veracity of one common design process (see Hennessy and McCormick, 1994 pp 94-108). What cannot be denied, however, is the importance of a practical curriculum for all to balance the academic. As Black would say, pupils need in technology "Minds on as well as hands on!" (Black, 1994)

- economic importance

The link to vocationalism is clear. In the UK, technology in schools was heavily promoted in the 1980s by the Technical and Vocational Education Initiative (TVEI). Funded by the then government department for industry rather than education, it marked a political identification that the promotion and health of school technology was being linked to the country's economic performance. The place of technology in vocational schools in so many European counties confirms this link, but also clouds the issue for those striving to promote the subject in academic schools. In Northern Ireland, for example, the desire to make 'Technology and Design' a subject considered appropriate for high-attaining Grammar School pupils has given it a particular emphasis quite different from England and Wales.

Curriculum emphases

In figure 1, I attempt to lay out four different areas about the subject which need to be addressed by whatever teacher professional development structure is in place. These are:

- The creation of 'school technology'
- The subject content knowledge of technology teachers
- Pedagogic knowledge
- Curricular knowledge

All the areas are closely inter-related and dependent one on another. Although teacher-education programmes need to specifically consider each of them, the focus, extent and time spent on each aspect will depend on the stage of development of the 'teacher-in-training' be it pre-service or in-service.

The creation of 'school technology'

The four aims outlined above have given rise to different approaches to school technology curricula which reflect both the combination and weight given to the various purposes for the subject, mediated by the current expertise of the majority of teachers who are required to implement it. The definition of the school subject is inextricably associated with who is available to teach it. In most western countries this has driven the curriculum towards a craft-based approach and a more-or-less strong desire to associate the subject with what are perceived to be the needs of the workplace. In very general terms, politicians have tended to emphasise economic importance and teacher dominated groups have rather stressed the intrinsic value of the subject.

The range of school technology curricula have been succinctly articulated by De Vries (1994 p 151 adapted and extended here):

- a craft-oriented approach, in which teaching how to handle tools and materials by making predesigned workpieces is the main context (as in the Swedish tradition of 'Sloyd' which underpins the curriculum history of technology education in many Western European countries)
- a production-oriented approach, emphasising skills appropriate to modern mass production, control and organisation (Eastern Europe)
- an applied-science approach, that sets all technology in the context of science learning (Denmark and also Switzerland to some extent)
- a 'high-tech' approach which looks ahead to the nature of life and work in the next century and emphasises Information Technology. In some senses technology = computers (a tendency in France and Germany)
- a technological-concepts approach, that teaches major technological theoretical concepts e.g. the systems concept rather than traditional materials base (a move in Australia, Queensland and in the USA to some extent)
- a design approach, where the process of designing new products is at the heart (Northern Ireland and largely England and Wales)
- a 'problem-solving' approach which concentrates on addressing social needs and takes a cross-disciplinary line (USA and Scotland)
- a key competency approach, in which the learning of competencies like cooperation, creativity and innovation are central (to some extent England and Wales)
- an STS (science, technology and society) approach that teaches about the relationships between science and technology. "One should observe that STS is almost always based on learning *about* technology, and there is a tendency to look upon technology as "applied science" (Håland 1992 p 258.) (Many parts of the world e.g. Greece, Canada (Alberta))

Some countries adopt one of these approaches whereas others try to implement a number of them together. The curriculum emphases are clearly matched to a vocational bias in some places and a general education bias elsewhere. However, it is by no means obvious which technology curriculum is the 'best' preparation for

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Figure 1

'School Technology'
(after de Vries 1994)

- Craft-oriented approach;
- Production-oriented approach;
- Applied-science approach;
- 'High-tech' approach;
- Technological-concepts approach;
- Design approach;
- 'Problem-solving' approach;
- Key competency approach;
- STS (science, technology and society) approach.

The subject content knowledge of technology teachers *For example:*

Nigeria: automobile technology; food & agricultural technology; building technology. (Balogun, 1989)

Hungary: industrial design; agriculture and technology; theory of systems; workshops in digital and analogue electronics (Kedves, Gergely, Kiss, 1989).

England and Wales: control systems (mechanisms, pneumatics and electronics); structures; resistant materials (metal, wood, plastics); textiles; food technology.

Why teach technology?

- its intrinsic value.
- education for citizenship
- education for capability
- economic importance

Pedagogic knowledge

General pedagogy
For example:

Classroom management;
Planning lessons;
Teaching strategies;
Evaluating and assessing
Pupils' understanding.

Subject methods
For example:

Circuit Boards & kits
Demonstrations &
Use of analogies
Construction techniques/tips
Teaching designing
Addressing Values

Curricular knowledge

Knowledge of syllabus & national curriculum requirements.

Knowledge of curriculum resources

For example:

Nuffield

STEP

TEP

RCA

Mission 21

↑

Philosophy
Psychology
Sociology

economic success (See Banks 1994). Japan, for example, does not have a general technology education curriculum for all although it does offer Industrial Arts in Lower Secondary Schools and has an extremely well structured vocational training system integral to 'lifetime employment'. (Ishikawa u.d.)

These different curricular emphases have implications for the subject knowledge of the staff required to teach the subject in school. Some definitions see the science teacher, and particularly the physics teacher, as the curriculum leader whereas in others it is the craft teacher. In both cases, however, the new curriculum has boundaries wider than that which they previously taught, and for which their own higher education (by either a concurrent or consecutive teacher education model) has prepared them.

The subject content knowledge of technology teachers

In Nigeria, a teacher's technical studies programme includes automobile technology, food & agricultural technology and building technology (Balogun, 1989 p72). In Hungary a two-subject teacher education curriculum in physics and technology might include industrial design, agriculture and technology, theory of systems, and workshops in digital and analogue electronics (Kedves, Gergely, Kiss, 1989, p179). The school technology curriculum in England and Wales is particularly broad embracing the teaching of control systems (mechanisms, pneumatics and electronics), structures, work with resistant materials (metal, wood, plastics), work with textiles, and food technology. The subject knowledge base expected of prospective technology teachers is, therefore, very broad.

Agnes Toth in a questionnaire analysis of technical teacher training in nine European countries noted:

> "In other forms of teacher training such as teacher training for mathematics and physics it is common that the students prepare for teaching two subjects [....]
>
> Quite differently, it is impossible to separate one or two engineering subjects within the system of engineering studies. The content of an engineering subject must be taught in relation to other subject elements if the whole of the subject is to be understood (e.g. mechanical components cannot be taught without mechanics, machines without fluid dynamics, electronics without the basics of [electricity] etc.) The connections among subject areas multiply when solving problems. [.....]
>
> [In examining the proportion of the engineering module within the total training...] This proportion is above 90% in Austria and Italy, it is 75% in the UK and Hungary, 66% in Holland, about 60% in France and about 50% in Germany.
>
> Thus a technical teacher prepares not for one or two subjects but for a whole engineering area. It has been proven in practice that the level of training is not lower because of this. Moreover, by having wider engineering knowledge technical teachers can adapt themselves to the specialisation of technical secondary schools without difficulty and they can also accept changes in the content of subject areas more easily."
> (Toth, 1995 pp 44-45)

This rather optimistic evaluation is not shared universally. In Queensland, Australia for example, the wide variety of courses available under the broad heading of manual arts (including skills based pre-vocational courses and senior courses in Engineering Technology) led Morgan and Wheeler to suggest that

> "We have little choice but to go to a systems approach. Philosophically, the notion of a knowledge and skills base arising from broad conceptualisation appears to have greater merit than that related to specific materials. Pragmatically, there is insufficient time in the degree to teach all the materials areas specifically, and the State is not

> prepared to employ a technology teacher who is only a "wood expert" or a "metals expert". (Morgan and Wheeler, 1992 p 184)

As is clear from the above, even what should be included as a common subject knowledge base, with its own set of concepts, is difficult to define. This tension between the need for a large range of science and engineering knowledge and a sophisticated skills base has been particularly acute in those countries such as the Netherlands and the UK where the new generation of technology teachers do not have the same knowledge base as the existing teachers in the classroom. For example, a survey in 1994 of 1,954 current full-time technology teachers in England and Wales showed that they "came from a wide variety of backgrounds and offered a diverse array of specialisms. Just over half the full-time teachers (53.2%) were from craft, design and technology (CDT), nearly a third (32.5%) from home economics, with the rest evenly spread between art and design (4.9%), business studies (4.8%) and information technology (4.7%)" (Smithers and Robinson 1994 p 6). The new entrants to the profession are similarly drawn from a wide, but different, background. Of those on one-year post-graduate pre-service courses in 1993 "engineering is now the main source of recruits (34.5%), followed by design (23.4%) and science, mathematics and computing (14.8%). The various practical skills of catering/home economics, textiles, furniture making, jewellery making, and building together only comprised 14.8%." (Smithers and Robinson, 1994 p 16). There seems from this evidence to be a swing in the UK away from recruitment of those student teachers with mainly practical skills towards an emphasis on "applied science". However, the teacher recruitment market there is very volatile indeed, and tends to inversely mirror the general economic situation. As everywhere, when the economy is buoyant, fewer people consider technical teaching as a career.

Many countries see an industrial experience as a prerequisite for technology teachers and this is considered essential for those working in vocational schools. In the industrial-production approach which was particularly strong in Eastern Europe, the industrial placement is thought to be one of the most important elements of training. In Austria and Italy an industrial practice is seen as a precondition for employment as a teacher in technical education, whereas teacher training itself is not and may be obtained as in-service education later. In societies where there is high mobility between professions, some new teachers with experience of the workplace are prepared to leave industry and to enter teaching despite the lower rates of pay. This naturally involves a teacher-education mode which supports the transition and I discuss that later in relation to Open Learning. Experience of industrial practice is not only important because of the links between school-work and the use of technology outside the classroom. Teachers need to also be aware of the values implicit in any technological product in terms of the impact of that product on the environment and the way technical production influences people's lives. (See Martin, 1992, Banks 1993 , Jephcote and Hendley 1994, & Conway and Riggs 1994 for ways in which a consideration of 'values' may be undertaken in school technology and in teacher education.)

The depth of subject knowledge seems to be linked to the different teacher education traditions. There are those students recruited from upper secondary school to be educated as teachers of technology in a concurrent "one-way street " model (Buchberger & Gruber, 1995 p A19), and those recruited later, often for consecutive courses after an academic training (and often industrial experience) for a different profession. In the former case the academic preparation has been tailored to the particularities of "school technology" and may lack depth or a real understanding of how that knowledge is applied. In the latter case, the teachers may have great depth in a rather narrow field, lacking the wider skills and knowledge. These older student teachers may also have a particular view of the purpose of school technology at variance with that promulgated by those who have 'invented' the school subject (See Banks 1996).

Toth (1995 p 50) noted that "The shortest engineering practice in technical teacher training is organised in Hungary where the curriculum prescribes only a four week engineering practice for would-be teachers of theoretical technical subjects". This comment suggests two things. First that there can be a relatively clear separation between "theory" and "practice" in technology and second there are those technology teachers who need a high practical ability and others who do not. Such a separation in a training course may be a pragmatic solution dictated by the constraints of time and the pressure on content (See Morgan and Wheeler above) but the separation of 'declarative' knowledge and 'procedural' knowledge is not straightforward (See McCormick 1996). In the preparation of technology teachers, skills of problem-solving, and the development of a procedure of designing-and-making are often taught by doing. To a large extent, the knowledge technologists have is tacit. This makes techniques for teaching in this new area particularly important.

Pedagogic knowledge

Newman (1994) reporting on aspects of the Council of Europe's work in relation to technical and vocational teachers states:

> "There should also be more emphasis on pedagogical skills. It was never safe to assume that competence in a vocational specialisation was enough to ensure effective classroom teaching, particularly in catering for the wide range of abilities and backgrounds characteristic of classes today" (p 8)

This quotation illustrates the way that in some countries technological education is mainly part of adult education. However, even for technology teacher education linked to preparation for school work, and where there is a clear recognition for the need for pedagogic skills and knowledge, there is a variation in opinion of how 'theory' should link to 'practice'. It is in relation to pedagogic knowledge that a mismatch between the personal rationale of the teacher for school technology and that of external curriculum planners is most marked. For example, if teachers see that their principal aim is to impart 'practical skills for the workplace' via a transmission model of teaching, they will not value (say) teaching strategies which encourage cooperative consideration of the values implicit in the use of particular materials.

Very little research has been conducted in the ways pupils learn about technology; much less than, for example, the way pupils' understanding is constructed in science. As a consequence much of the pedagogy taught in pre-service courses, even in countries like the Netherlands and the UK with a strong practicum focus, tends to be general. In other countries, such as Hungary, Ireland and Austria academic subjects such as philosophy, psychology and history of education are prominent and the student is expected to assimilate the knowledge gained and translate it into intelligent practice in the classroom. Such an approach is considered by many to be "too theoretical and too remote from the practical" (Archer and Peck 1991 p 58) and students often fail to see the direct relevance (See Banks 1996). Varga (1995) in a study of the theoretical training of technical teachers from five European countries makes a distinction between 'didactics' and 'special didactics or methodology', and Banks et al (1995) would also separate general pedagogy from that required for specific subjects. Both sorts of 'didactics' are covered by all countries and involve topics such as classroom management; planning lessons and teaching strategies; evaluating and assessing pupils' understanding. 'Subject methods' relates closely to school practice in all systems and would cover such matters as interpreting syllabus content and sequencing lessons. I consider this in more detail under modes of delivery later when I also consider school teaching placement and the notion of 'mentoring'.

Curricular knowledge

The final 'curriculum emphasis' would relate to a knowledge of the resources to teach technology: curricular knowledge. Those who have worked in systems which have a list of prescribed textbooks, such as Greece, Luxembourg and some states of the USA, will be acutely aware of the need for high quality resources. In reporting on a time he served as a member of the State Board of Education, the physicist Richard Feynman has put his views on poor classroom materials strongly:

> "Everything was written by somebody who didn't know what the hell he was talking about, so it was a little bit wrong, always! And how we are going to teach well by using books written by people who don't quite understand what they're talking about, I *cannot* understand. I don't know why, but the books are lousy; UNIVERSALLY LOUSY!" (Feynman 1986 p293)

Curriculum resources are the life-blood of any subject, and in such a new subject as technology, they can strongly influence both the subject content and the pedagogy of the classroom. For example, in the UK the National Curriculum Order for Technology was deemed to be not working before authors and the publishers had produced resources to support teachers in the classroom. It is indicative of the speed of implementation in the UK that time was not taken to do this, unlike the more measured approach of other countries.

New materials such as those provided by Nuffield, Staffordshire Technology Education Programme (STEP), the Technology Enhancement Project (TEP) and the Royal College of Art (RCA) all have a strong pedagogic line. They separate out inputs from the teacher, or suggest special focused tasks for the pupils to provide a particular knowledge or skill requirement within the structure of a longer series of lessons or project. The materials provide a structure to open-ended work and reduce the need for 'knowledge on demand', which teachers find difficult, but also can help to provide such ad hoc information when it is required. In this way the curricular knowledge of what is available to teach the subject impacts directly on the way lessons are planned and the subject programme is devised. Like STEP, Mission 21 from Virginia, USA (sponsored by NASA) provides resources to promote problem-solving by elementary school pupils. These materials support, but alter the emphasis in the existing elementary school system.

The extensive curriculum development innovation of the 1960s has taught us many lessons. It was initiated, it may be remembered, by the optimism for all things scientific in the previous decade and funded in the West by the political sea-change in concern for the state of science and engineering education brought about by the launch of Sputnik. Curriculum projects in science, mathematics and humanities were developed as 'whole packages' which were innovative in content, materials and classroom methodology. Without a clear rationale for the change established amongst the classroom teachers, and no provision for those teachers to readily 'take ownership' of the new development, the overall impact on the curriculum was generally disappointing.

Technology as a general subject in many countries is in an unique position. There is no established way in which it 'should be taught' and teachers, although naturally sceptical of any changes, do not have such deeply entrenched opinions of appropriate pedagogy as is the case in subjects with a longer tradition. However, the warning about the lack of understanding about how pupils learn aspects of technology should be heeded. Classroom methods to promote "I do and I understand" can so easily become "I do and I am even more confused"! The new technology curriculum projects mentioned above give the classroom teachers planning frameworks, classroom materials and exemplar schemes, but are also enabling teachers to alter the programme to suit their context. The back-up in-service provision should not only give guidance to the teachers on the curriculum materials, it should also help them to be reflective on the way pupils are learning about technology and so on the general effectiveness of their use of the scheme.

Modes of presentation

Who educates the student teachers, who re-educates the teachers in the classroom and who 'trains the trainers'? I give here an overview of some of the different ways that technology teacher education courses are presented. There is an emphasis on the more novel approaches as they suggest possible practical solutions to some of the problems outlined in the introduction. I consider four different types of provision:

- Institutional providers
- Mobile classrooms
- Open and distance learning
- New technologies

Institutional providers: Initial Teacher Education

The ITE (Initial Teacher Education) curriculum is highly centralised in some countries (raising the hope, at least, of a framework for continuing professional development) but is very laissez-faire in others. Technology education for all pupils cuts across three quite distinct initial teacher education traditions, all of which are in a state of change across the world. As discussed above, all ITE models have elements of education studies, academic subject studies, subject didactics and teaching practice but the emphasis and extent of the preparation varies across the different traditions.

ITE for intending primary teachers tends to follow the 'école normale' tradition of a concurrent model. This model emphasises 'practical' training and rather devalues both educational theory and academic preparation. There is a strong emphasis on being the 'right personality' for teaching and student teachers are inducted into schools by association with a mentor as 'master teacher'. School craft teachers have tended to be educated in this tradition in the past.

The preparation for teachers of upper secondary schools has generally been in the 'academic' tradition. A thorough academic preparation followed (more or less consecutively) by exposure to the education foundations was assumed to prepare student teachers to work in the 'studious' atmosphere of the schools. Again, education theory, methodology and school experience is rather neglected. Science teachers have tended to be educated by this model.

ITE for teachers of technical vocational subjects has generally been shorter than in the other traditions (for example 2 years in Austria) as the student teachers have been assumed to already possess high practical competence and be more mature. In many countries (such as Denmark and the UK) teacher education for these students is part of in-service provision. Some countries such as Belgium and the Netherlands provide ITE for vocational subjects at lower secondary level, and others such as Germany and Czech Republic have introduced special programmes for teachers of 'practical subjects'.

Developments of all these traditions over the last few decades have led to a greater professionalisation of the teaching work-force. The main components of such a professionalised teacher education have been described by Buchberger (1994 p 27) and conform well to the aspects of teacher knowledge described in figure 1 above, but with the additional emphasis on:

- coherent and supervised practical clinical studies, and
- the integration of studies in the sciences of the teaching profession and clinical studies.

In the USA, too, there are proposals to move technology education away from the teacher education curriculum of the industrial arts. Scott and Buffer report

> ".. the Holmes Group have proposed that all teachers receive a comprehensive liberal arts education, and that most teacher education courses be shifted to the graduate level. This model also calls for new interrelationships or internships between teacher education programs and schools (called Professional Development Schools) very similar to the teaching hospital model in the medical profession. The model also allows for the development of career ladders or differentiating staffing of teachers and the implementation of an induction year into the teaching [profession] using master technology education teachers as mentors for internship or new technology teachers." (Scott and Buffer, 1995 p458)

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Although the UK has been swimming against the general European tide of increased teacher professionalism in recent years, the long established Oxford Internship scheme and other more recent 'school-based' teacher education programmes initiated by other institutions has relied on the development of just such subject mentors as Scott and Buffer describe. This concept of mentoring extends to induction of new teachers and the need to consider continued professional development. A mentor is more than a general supervisor or "patron de stage" as exists in Luxembourg. He or she is an 'expert teacher' who has been trained by the ITE institution to take on some of the subject-based teacher education work within the school context. Anderson and Shannon (1995 p29) are typical of the literature on mentoring when they describe the characteristics of good mentors as 'nurturing', 'role model', 'teaching, sponsoring, encouraging, counselling and befriending' and 'ongoing caring relationship'. However, as Banks (1996) points out, such a conception underplays the need for subject-specific guidance in the classroom. Too much mentor-mentee dialogue tends to focus on general classroom management and control and too little on pedagogic strategies for the classroom. This is a particular problem for a subject like technology where, more than ever, teachers look to the students to bring along 'new ideas'. However, the mentor working alongside the student teacher virtually on a one-to-one basis is in an excellent position to identify and help to rectify subject knowledge skill and gaps. Working to a common subject audit (e.g. DATA 1995) both the student and mentor can work together to ensure a minimum level of subject competence is reached.

Institutional providers: In-service Education and Training (INSET)

A general criticism of teacher education has been that it has had a static conception of professional preparation and a 'rucksack' philosophy. All a teacher needs to know is loaded on him/her at the ITE stage.

This is clearly an inadequate situation for all teachers and particularly for those involved with technology. In the case of ITE the teacher education emphasis may be on general pedagogic knowledge, but all teachers need to develop their subject content knowledge in this rapidly changing field and the associated curricular knowledge (curriculum and methodology) too.

An analysis of 29 providers of technology INSET in the USA (Table 1) revealed the following as the major focus of activity.

It is perhaps inevitable that the emphasis should be on technology updating and curriculum development. It should be noted that methods of implementing curriculum change, and some work on its possible evaluation is done too. But it is in the areas of subject knowledge deficiency that teachers themselves see an immediate need. A survey sponsored, by the Nuffield Foundation, of 500 teachers in England and Wales was conducted three years after the introduction of the compulsory National Curriculum. The results regarding subject knowledge are illustrated in Tables 2A and 2B. Recent recruits to teaching were twice as likely to feel adequately trained as those who have been teaching for five years or more. However, design and technology teachers in the sample were, as a group, generally older than other teachers in schools, often with many years teaching experience. For example, 78% of the design

Table 1

Table 1

Focus of In-Service	Number of institutions	Percent of Institutions
Technology update	25	86%
Curriculum development	24	83%
Student learning activities	19	66%
Teaching methods	18	62%
Curriculum integration (Math, Science, & Tech.)	16	55%
Philosophy	14	48%
Other (Classroom research)	4	14%

(Boser and Daugherty, 1994 p9)

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and technology teachers had been teaching for at least 10 years. The case for further teacher education is self-evident. However the teaching strategies adopted by technology teachers need to be widened too, especially as the curriculum increasingly involves the teaching of designing and scientific principles.

Yet there are financial constraints and practical problems here. In many countries the organisations responsible for ITE and for INSET are different (most teacher centres in Spain, IRRSAE in Italy and the many Länder of Germany). Universities assume that role in France, but the ITE institutions are involved in Iceland, Ireland and the Netherlands. The co-ordination of ITE with further professional development is not easy with a mixed system. The finances for such activity come from diverse places (some national, some regional), some industrial or private (for example NASA, and the Engineering Council in the UK), and from the teachers' own pocket as attendance at INSET events is seen as a stepping stone in a teacher's career. This is particularly prevalent where INSET priorities moves away from personal development to whole-school improvement. The timing of INSET is also a problem as school-time provision takes the teacher away from the pupils whereas out-of-school time, particularly involving long trips to a training centre, cuts into a teacher's personal life.

It is obvious that an infrastructure of locally provided in-service training, which involves teachers in the planning, will be mutually beneficial to the teachers and to those ITE institutions and local education boards who wish to establish centres of classroom excellence. Yet such systems have been under severe financial strain in recent years.

Table 2

Table 2 Part A

Element of national curriculum design and technology (D&T)	% of teachers with no training *at all* in the element
	%
Business	78
Hydraulics	41
Computer Control	34
Pneumatics	34
CAD	31
CAM	27
Graphics	26
Plastic	25
Electronics	24
Electricity	19
Food	19
Ceramics	17
Mechanisms	14
Textiles	14
Design	13
Wood	13
Structures	12
Metal	8

(DATA 1994)

Table 2 Part B

Element of national curriculum technology	% of teachers who consider *themselves* to be inadequately trained to teach a particular element of D&T
	%
Design	75
CAD	54
CAM	53
Electronics	52
Computer Control	51
Pneumatics	48
Hydraulics	46
Business/ Economics	42
Graphics	27
Structures	27
Mechanisms	24
Electricity	20
Textiles	19
Food	17
Ceramics	17
Plastic	14
Wood	12
Metal	7

In the survey by Boser and Daugherty reported above, they recommend "offering workshops at nominal (or no) cost to attract greater numbers of teachers" and "Given continual pressure on institutional budgets, colleges and universities need to find ways of funding in-service on a consistent basis, independent of institutional funding." (p14). In the UK, the extensive network of local education authority advisers has all but disappeared. Increasingly private organisations (often the same advisers now privatised) are competing for the scarce training funds along with publishers who wish to promote their curriculum materials or organisations backed by industry who wish to give a particular (often vocational) emphasis to the general technology curriculum.

Mobile Classrooms

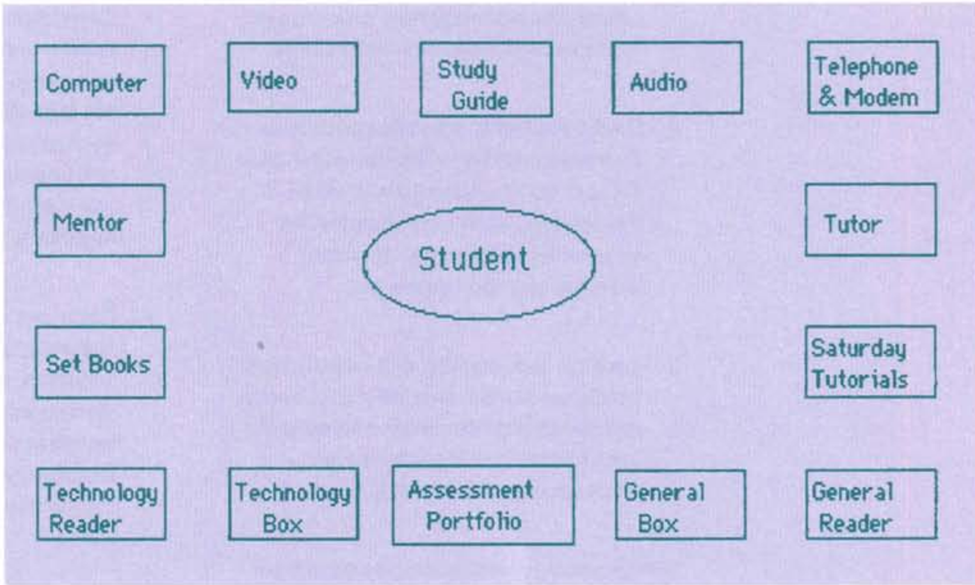
One successful strategy for providing local resources for technology teacher education in remote areas is the provision of mobile classrooms. These were established in the UK during the 1980s, using government pump-priming funds, by British School Technology operating out of Nottingham Trent University. Using specially adapted buses, groups of teachers were able to meet for four one-week courses on such topics as problem-solving, pneumatics and electronics. The local site cut down on accommodation costs and minimised other disruption and the courses, which were prepared and serviced centrally, could be designed for a known environment. The emphasis of the courses was on technology updating, and a craft teacher and a science teacher from the same school came to learn aspects of the subject which they could introduce into what was then an unregulated school curriculum. This strategy still exists, now using funds from industry to support the WISE (Women into Science and Engineering) project. Following courses for pupils, up to 16 girls can be accommodated on each bus which are each 12 metres long, 3 metres wide and 3.5 metres tall. Using power supplied from two 13 amp sockets, the pupils carry out a range of activities including Computer Aided Design, Systems Electronics, Pneumatics, Computer Control and Structures. Like the teacher courses, the emphasis is "hands on" experience. With such an approach, however, teachers do not have the time to consider easily the teaching and learning strategies which they might adopt in the classroom. Expert teachers who are to become mentors require that reflection which necessitates a longer period of study.

Open and distance learning

Open and distance learning has a number of benefits for teachers who wish to consider the wider implications of technology education for all. It is relatively cheap, teachers can study part-time when it is mutually convenient to them and their school, and they can more or less study at their own pace. Although it is possible to conduct practical work using home-experiment kits, for the situation of teachers it is usually better that they do practical work either using school facilities or on separate residential weeks. The Open University (OU) currently offers post-graduate technology teacher education courses at pre-service, in-service and at Master's level. Using specially prepared study materials all those involved in teacher education, including teacher 'trainers' themselves, can engage in professional up-dating over a sustained period without major disruption to their normal duties.

The materials are "multi-media" in the sense that they exploit the strengths of different traditional means of communication as well as using more modern devices such as video and computers. In the case of the pre-service course, students are required to engage in 18 weeks of full-time school experience in addition to their part-time studies. The course is directed from a text-based study guide which links together the different components; resource boxes, video and audio cassettes, school experience activities and computer-based resources (See Figure 2). All OU courses, however, draw heavily on the experience of teachers (or others involved with teachers) in the preparation of assignments. They are required to develop an enquiring attitude to the implementation of the new curriculum and, at Master's level in particular, are given evaluative tools to thoroughly investigate the effectiveness of curriculum change. In 1996 over 400 students will be studying technology teacher education courses with the Open University, and thousands more (some of them teachers) on technology

Figure 2



subject courses offered by the OU's technology faculty.

Open Universities exist in many countries around the world operating on the same principles of cost-effective mass-education systems. Distance learning is being used by other INSET providers too. In South Africa, for example, the ORT Science and Technology Education Project (ORT-STEP), which was established in 1993, has begun a systematic programme of pupil and teacher training, including 'training the trainers'. Although operating mainly from local centres which give technology courses to pupils, teachers and adult basic education on a time-share basis, ORT-STEP is beginning to establish distance-learning courses using interactive satellite communication. To many people 'distance-learning' and 'multi-media' are synonymous with new technologies. Satellite communication, video conferencing and E-mail are used in many countries and, in the case of E-mail in particular, can be instituted relatively cheaply. This is a particular benefit in countries where terrestrial 'snail-mail' is unreliable (See Proc. ICDED 1994). It is to the use of new technologies that I now turn.

New technologies

Sometimes new technologies are used to mirror the conventional, even traditional, approach of higher education. For example, the use of simultaneous satellite broadcast of standard lectures from one campus to another site. At the off-campus site the small group of external students can make similar notes and, if there is a two-way link, ask questions at the end of the lecture. The external link could be anywhere in the world and the preparation by the faculty member need not be any different. Indeed, the idea has been 'sold' to faculty members in some universities in the USA by convincing them that it is just "business as usual"! Such education may be 'distant', but it is not 'open'. New technologies need to be used to break the synchronous nature of teaching (especially when this involves different time-zones) and exploited in ways which are most appropriate to the learning intentions.

Already computer conferencing is being used to support learners whether they have easy access to INSET providers or not. Within an electronically enclosed "walled-garden", students can provide mutual support, send and receive classroom resources , gain access to tutors at mutually convenient times and also communicate with other specialists who have been invited to contribute to discussions (Selinger, 1995). This is separate and in addition to access to the Internet where multi-media materials are increasingly accessible if, currently, rather slowly. In 1992, Duby predicted with some accuracy the technology education system in the year 2000:

1. It will be a highly interconnected system: students, teachers, libraries, and information providers will be interconnected at schools, homes,

enterprises and anywhere else through high bandwidth communication links.

2. It will be a highly data integrated system. Everything will be on the computer and, if it is not on the computer, it will be on the network. All kinds of data will be accessible: text, image, simulated experiments, courseware etc.

3. It will be user friendly, with more human interfaces (image, handwriting, speech) and specialised terminals tailored to the user abilities and the application requirements. (Duby, 1992, p 41)

The situation in 1996 is already almost as Duby predicted. Information about technology teacher education provision on the Internet, for example, is available on site: http:/www.engc.org.uk/tep://index.html. and further details about what has been described as "knowledge media", especially with respect to open and distance learning, may be found at http://kmi.open.ac.uk/kmi-misc/kmi-feature.html.

Conclusion

This overview has ranged widely from a consideration of traditional models of initial teacher education to the present and future use of new technologies for technology teacher education. There are a number of common issues for teacher education:

- The rationale for 'technology for all' still needs to be more widely articulated, especially as it impacts on teacher education.

- 'Minds-on as well as hands-on' applies to teachers as well as pupils. Technology update is important, but so is the development of teaching and learning strategies and means of evaluating the effectiveness of new curriculum provision.

- The development of 'expert teachers' to be mentors for student teachers and for new entrants will enhance all sectors of the profession.

- Curriculum development projects have a special part to play in introducing new pedagogy. Teachers need to be sure of the rationale for the development to enhance and adapt it to local circumstance. This implies a need to assist teachers with developing evaluative skills.

- Open and distance learning and new technologies are already making an important, cost-effective, contribution to teacher education. These methods will increasingly contribute to teacher professional development, even when the teacher has access to face-to-face tuition.

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