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ABSTRACT

During the last 35 years, due to the globalization of the world economy and developing technologies, a considerable change has occurred in secondary education. This publication explores the extent to which the development of science education should be linked to labor markets in developing countries. Sections include: (1) "Science Education, Labor Markets and Economic Growth"; (2) "Arguments for Links of SET [science education and training] to Labor Markets"; (3) "Arguments against Links with Labor Markets"; (4) "A Labor Market Metaphor for Science Education"; (5) "Strategies for Linking Science Education to Labor Markets"; and (6) "Concluding Remarks." (Contains 16 references.) (YDS)

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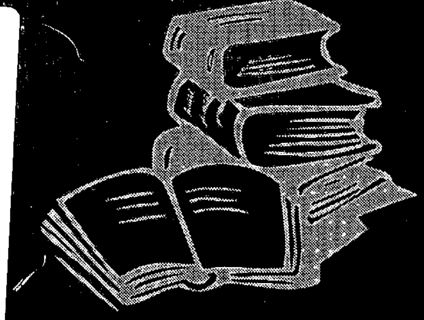
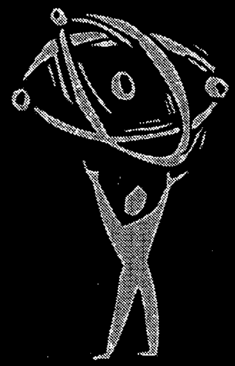
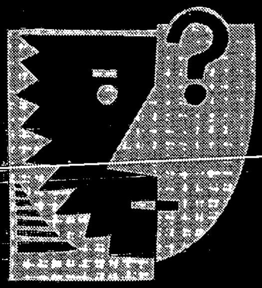
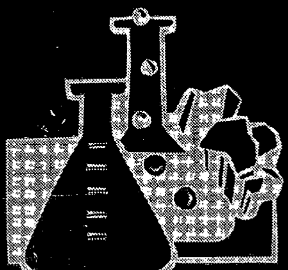


LINKING SCIENCE EDUCATION TO LABOUR MARKETS: ISSUES AND STRATEGIES

Keith M. Lewin







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Linking Science Education to Labour Markets: Issues and Strategies

Keith M Lewin

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Forward

Welcome to the Secondary Education Series of the Human Development Network, Education Group at the World Bank.

The World Bank has been assisting developing countries in their efforts to reform their secondary education systems for more than 35 years. During this period, the context and imperatives for education reform have changed considerably due to various factors such as globalization of the world economy and the impact of new technologies. This new environment requires rethinking the traditional way of providing secondary education and training systems and both industrializing and industrialized countries are grappling how best to prepare their youth to become productive workforce as well as responsible citizens. Thus, this series will address a wide range of topics within secondary education that reflect the challenges that we are facing now.

This paper, "Linking Science Education to Labour Markets: Issues and Strategies" is the third publication in the Secondary Education Series. Along with the second publication in this series, "Mapping Science Education Policies in Developing Countries", this paper was originally prepared for the workshop, the Secondary Science Education for Development (http://www1.worldbank.org/education/scied/Training/training.htm), which was organized by the Education Group in April 2000. The workshop aimed to explore some of the issues involved in science education reform within a larger context of social and economic development. We hope these two new volumes will provide with opportunities to further explore these issues with our clients. We welcome your comments.

World Bank
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About the Author

Professor Keith M Lewin (e-mail: k.m.lewin@sussex.ac.uk) is the Director of the Centre for International Education, University of Sussex in England and holds a Chair in the Institute of Education. He has twenty five years of experience in education reform in Asia and Africa. He also co-authored the book with François Cailloid and Gabrielle Gottelman-Duret, Science Education and Development: Planning and Policy Issues at Secondary Level (IIEP/Pergamon, 1997), from which this paper was developed.

Introduction

The purpose of this paper is to explore the extent to which the development of science education should be linked to labour markets in developing countries. As with many other areas of the curriculum there are tensions between those who argue that the structure of knowledge and ways of knowing should be the basis for the curriculum, and those who emphasise the importance of shaping curricula around students understandings and motivations and the utility of what is learned. This paper is in five sections. First, it presents four general observations about the roles science and technology have played in the development process. Second, it directly addresses the case for linking science education to labour markets. Third it considers some of the counter propositions which are advanced to oppose closer links. Fourth, a speculative metaphor is developed to suggest one way in which science education could evolve to resonate more closely with skills and competencies associated with some forms of production. Fifth, specific strategies for links are suggested.

Science Education, Labour Markets and Economic Growth

Development has at its core transformations in economic activity, living conditions and values that generate social change. For these to be judged to be developmental there has to be some consensus that some conditions of life are preferable to others. Thus, it can be argued that there is some agreement that freedom from disease is beneficial, adequate nutrition and food security are basic human needs that should be met everywhere, and improvements in the material conditions of life are desirable, e.g., access to adequate housing, clothing, communications, energy. Some would add to this an increasing long list of human rights that need to be satisfied, e.g., the right to education, a sustainable livelihood, the rule of law, equitable access to public services, and fair income distribution. The longer the list, the more contentious some of its components may be. The arguments in this paper are based on accepting that material well-being resulting from economic growth is a valued objective, productive employment or self employment is a necessary condition for growth, and investment in education and training is a necessary, but not sufficient, condition to promote development linked to increased productivity.

A simple view of development suggests that its basis is some combination of the ability to transform the physical environment, coupled with changes in how groups of people choose to organise themselves. These lie at the core of the development process. Development is therefore both a technological process and a cultural and socio-economic shift to more, rather than less, valued conditions of life. This paper focuses on science education and training[1] (SET) and its possible role in contributing to development through its links to employment and the application of science-based ideas. Four

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[1] This paper uses the term "science education and training" (SET) to include technological application of science. Its position is one which sees science education as part of a continuum with what is sometimes separately identified as technology education. Arguably technologised science education and science-based technology education share similar educational objectives and content.

observations set the scene for more specific consideration of links between SET and labour markets.

First, history contains a myriad examples of how economic development and social change have been associated intimately with changes in technology (see e.g. Diamond 1999). The development of agriculture released populations from lifestyles based on hunting and gathering, which at best were precarious. It enabled cultures to develop that generated surpluses and allowed complex patterns of social organisation to flower. Stable civilisations developed language, writing and mathematics that enabled an accumulation of ideas across generations and promoted ways of systematically improving the capacity to manipulate the physical environment. Large scale irrigation became feasible, metal based tool making became sophisticated, the construction of towns and cities became possible. The simple point is that without the development of technologies much if not all of this development would have been impossible. What distinguished those populations that developed complex civilisation at an early date from those that did not, was a combination of technological accumulation and innovation, acting in concert with other conditions (social stability, geographically favourable locations, purposeful leadership). Early technological innovation occurred before the development of what is now recognised as science. Nevertheless, such innovation did depend on what are now recognised as scientific thinking skills and sowed the seeds for the development of more and more systematic methods of enquiry into the natural world. The long sweep of history intrigues with many unresolved debates about the relationships between technology and development. The motives for technological development may well have been mixed. Some may be explained as enlightened attempts to improve the living conditions of individuals and communities. Others were more obviously related to the imperatives of war and conquest. The point here is that any historical account of development has to recognise the key role played by changing technologies. These technologies are shared and refined through what are essentially education and training processes.

Second, a brief reflection on the industrial revolution is relevant. Industrialisation generated rapid development in those countries that benefited first from the transformation of rural, agrarian-based production to economies based on manufactured goods (see e.g. Landes 1999, Landes 1969). The technologies that drove industrialisation may not have been the direct consequence of science as then practised. Many of the first innovators were poorly educated and practically, rather than theoretically, orientated. As the process unfolded it became clear that technological innovation increased in complexity and benefited from an understanding of the underlying science. Later generations of innovation, which resulted in comparative advantages in production, began to acquire the character of designed solutions to well specified problems explored using the intellectual and empirical tools for enquiry associated with science. The more it became possible to design solutions to production problems, the more successful and efficient the development process could be. Thus it became possible to design and build structures with more predictable properties, synthesise materials to substitute for natural products and create new materials, and act to reduce disease based on knowledge of its causes. No longer was it necessary to depend on trial and error.

Third, more recently there is at least suggestive evidence that the East Asian countries that developed rapidly in the latter part of the 20th century benefited from a highly educated labour force which had a relatively high level of skill endowment that was formally acquired (World Bank 1993). Basic education was well established and near universal in advance of periods of rapid economic growth. Most, but not all, of these countries invested substantially in secondary schooling, which included SET. Much of the export led growth that they experienced was in high value added products with high knowledge content. Many of these products and the associated production processes had a scientific and technological base. The story of rapid development in these countries is complex and not all of the factors advanced to explain their success relate to investment in science and technology. However it is clear that some do, and that without such investment in SET, growth would have been compromised.

Fourth, globalisation is changing ways in which production is organised and the characteristics of labour markets. This has implications for SET. Development is associated with changes in the proportions of the labour force employed in agriculture, manufacturing, and services. Links between SET and the labour market have to be conceived in terms of the proportions of employment in the different sectors, and the nature of the production process. Strikingly the development of new information and communication technologies (ICTs) is transforming production and employment (Dicken 1998). Manufacturing and services increasingly depend on knowledge-based work dependent on ICTs. This has created demands in developing countries for highly skilled professionals who can provide ICT based services competitively and who may market these internationally. It has also facilitated the migration of lower level jobs based on information processing to developing countries. The "digital divide" between countries is becoming and increasing matter of concern. Though the adoption of ICTs is not directly related to SET, the infrastructure on which ICTs depend is. So also, at least in part, is the development of software which depends on the logical thinking and deductive reasoning that can be associated with SET. Leading countries in the information and communication revolution all have quality SET systems. The links between investment in SET and the use of ICTs may be diffuse, rather than specific. It is difficult to suppose that they are unimportant.

These preliminary observations lead to the following proposition. Economic development is widely associated with advances in technology. Technology benefits from investment in SET, though clearly the constructive application of technology depends on many other things. Linking SET to application and skill, and hence to competencies valued in labour markets, appears to have a wide range of possible benefits. We now turn to consider specific arguments for and against promoting links between SET and the labour market.

Arguments for Links of SET to Labour Markets

Six main arguments for links with labour markets seem pertinent:

First, investment in education and training in science and technology appear to be necessary but not sufficient condition for economic development. Historical perspective on development, whether in the distant past or more recently, attribute great significance to the interplay between the development of technology and social and economic transformations. Many basic technologies may have been the product of trial and error, rather than knowledge-based solution searching. They may have benefited from inspired guesswork rather than the result of any research and development process dependent on an understanding of scientific principles. Two developments have changed this. Science has evolved from small scale enquiry into the natural world into a vast accumulation of knowledge, information and understanding which is widely accessible to those with problems to solve. Technology, understood in terms of the application of ideas to processes and products, has become much more complex and dependent on an accumulation of ideas and analytical processes. In short, the entry prices to new technologies have escalated to an extent that makes it unlikely that those without formal education and training and an induction into scientific knowledge and thinking will develop the technologies of the future. If this is so, and if technologies based on but not determined by scientific understanding hold one of the keys to development, then linking SET to economic activity must be advantageous.

Like many of the most interesting propositions in development, it is not possible to prove unambiguously that investment in SET leads to increased rates of development. Attempts to link participation rates and other indicators of investment in SET with development indicators do not lead to simple associations or clear causal relationships (Caillods, Gottelman-Duret and Lewin 1997). This is not surprising given the number of factors that may determine the quality of the investment in SET, the rate of economic growth and improvements in other forms of social well being.

Nevertheless two things can be noted. First, the counter proposition that somehow it is developmentally desirable to minimise investment in SET, is almost never advanced. It is so counter intuitive that it holds little sway. The arguments are much more about what kind of SET is likely to be most beneficial and affordable. Much of what needs to be known to reduce poverty, malnutrition, and disease is known in a technical sense. The problems revolve around whether those who need to know have access to and understanding of the ideas as well as the relevant technologies (an education and training problem), and whether when they do complementary conditions for the successful application of technology are satisfied (a socio-economic and political problem).

The second point is that the evidence there is from economic analysis supports the view that investment in education and training is a major factor in creating the conditions under which development can accelerate. There is a vast literature exploring the benefits of investment in human capital which puts the case that growth and development cannot be explained by increases in traditional factor inputs alone (land, labour and capital).

What growth remains unexplained may be best understood as the result of increases in productivity that arise from improvements in the knowledge and skill of the labour force and changes in technology. The arguments and the evidence need no extensive repetition here (Lewin 1995a). However, it is of interest to draw attention to some analyses of relevance to investment in SET. These suggest that it is investment at secondary level and above that is most closely associated with the export-led growth experienced by a range of rapidly developing countries over the last two decades (Wood and Berge 1994). This has been especially significant for the rapid growth that East Asian countries experienced in the 1970s and 1980s (Wood Ridao-Cano, 1996:27; Asian Development Bank 1997). We can note that cross country correlations of GDP and gross enrolments rates over time do not show a relationship between primary enrolments and GDP. Secondary enrolments do seem to be positively correlated with GDP ten year later – countries which have high levels of secondary schooling tend to be amongst those with the highest GDPs ten years later. Though this does not demonstrate causality it is at least consistent with the view that investment in secondary schooling is a contributory factors to GDP growth. The most recent analysis (Wood and Mayer 1999) argues strongly that rapid skill accumulation was achieved in East Asia through simultaneous expansion of education and step by step upgrading of the skill intensity of industrial activities. This raised demand for educated labour and provided training opportunities post school. Other evidence from Africa indicates that those with secondary schooling benefit cognitively directly and substantially from their participation (Knight and Sabot, 1990).

These observations invite speculation of the reasons why secondary schooling might be important. Effective secondary schooling offers access to abstract reasoning and the kind of flexible thinking skills associated with growth-orientated production and new jobs in manufacturing and the service sector, which have an increasing information processing and knowledge content. An under-supply of these skills is often seen as a constraint on development. The areas of the secondary curriculum that are most likely to contribute to the development of reasoning and skills are SET and mathematics. Links between these and the labour market therefore make sense.

Third, globalisation has many ramifications. One of these is that the technology balance may become more and more unequal (Mansell and Wehn 1998). The enforcement of intellectual property rights, coupled with changes in the ways in which wealth-generating technologies are developed, poses a threat to the free flow of innovations that can transform the development landscape. More than ever before, technologies are becoming proprietary. Patterns of patent registration illustrate that in most developing countries very small numbers of patents are registered by residents and much larger numbers by non-residents. Biotechnology and genetic engineering are creating high yielding pest resistant varieties whose prices and availability are controlled by a small number of multi-national companies. Branded drugs are marketed at many times the price of their generic equivalents. The logic of the market place is to diminish the availability of these generics. Recent debates over the pricing strategies for HIV/AIDs drugs are but one example. Increasingly software is being rented on a subscription base rather than sold. This may lead to poorer developing counties being marginalised further from main stream developments in information and communication technology (ICT). If access to telecommunications and software is priced to reflect what rich country markets will bear, the digital divide, between those countries with extensive use of ICTs and those without, will increase.

An implication of globalisation is that national science and technology capability is becoming more, rather than less, important. If the privatisation of science and technology continues it calls into question development strategies based on the technology transfer and adaptation. Legal obstacles will be erected to discourage transfers, or allow them under circumstances where rights are licensed for a price. The mature technologies which are available to developing countries without much hindrance will become fewer and fewer. If national science and technology capacity exists there is at least some room for optimism that new technologies can be developed that address the needs of developing countries in ways where ownership is at least in part shared. The ability to adopt, maintain and improve will be severely curtailed if it is dependent on the grace and favour of visiting specialists rather than grounded in a viable national system of SET.

Fourth, in one sense the case for linking science education to labour markets is already made. From the 1960s it has been difficult to find national plans relating to education and training that do not emphasise the importance of developing capacity in science and technology (Lewin 1985). Education development plans frequently stress this as a central plank. Human capital theory, the underlying philosophy behind most such plans, is based on the potential for education and training to transform capabilities in ways that lead to increased productivity. The conversion of these capabilities into knowledge and skills in the curriculum leads to advocacy of more technology in the curriculum, pre-vocational and vocational studies, and the need for specialised support in this area for different groups.

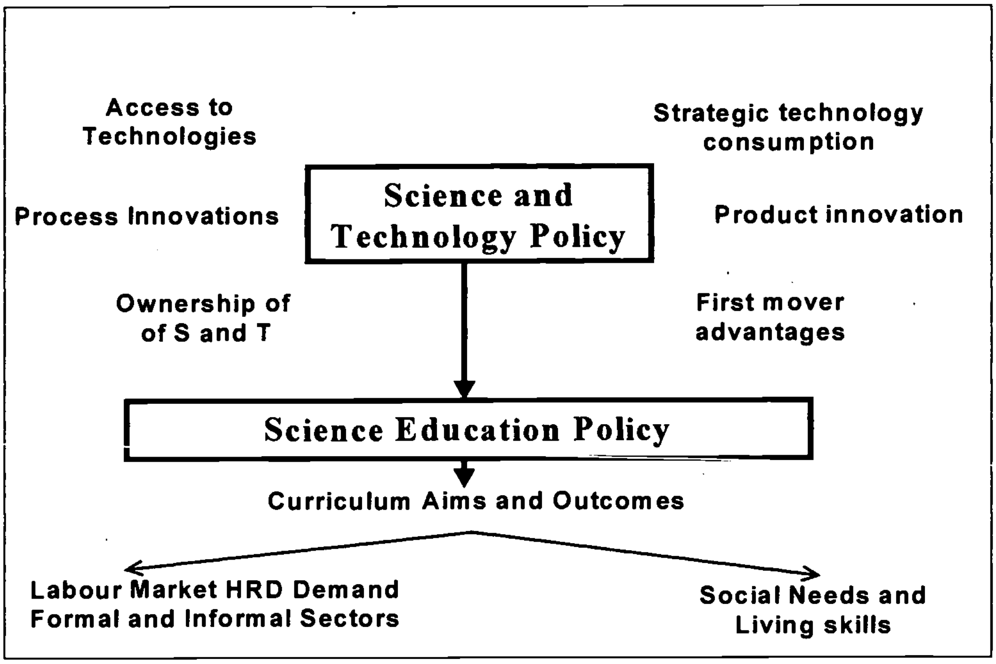
Parents and students value employable skills derived from schooling. Effective demand for these is strong, especially in labour markets where access to jobs if determined by qualifications linked to competencies. The demand for those qualified in SET is specific to different labour markets. The demand comes in two forms – jobs that specifically require SET and jobs where those with SET qualifications are preferred. Labour market signals often indicate shortages of science and technology human resources in developing countries. Where this is so this strengthens the case for enhancing links to the labour market.

Fifth, we can note that science and technology education are likely to have significant externalities. Key problems in development benefit from public understanding of science and technology that is widely dispersed across the population. Adequate nutrition depends on an appreciation of the principles of a balanced diet. Health is closely related to systematic appreciation of the causes of ill health and the ways of avoiding disease and treating common ailments effectively before they become debilitating. Sustainable development related to land use and environmental preservation is more likely where most of the population share fundamental understandings of ecosystems and their interdependence. All these attributes are more likely to be promoted in the SET elements of the curriculum than in other subjects.

Sixth, SET is relatively expensive. The reasons for this are a mixture of genuine needs (to support some kind of practically based learning, to use specialised equipment and facilities), and those which can be challenged as desirable but not essential to effective science and technology teaching (high cost laboratory provision, small teaching groups). Some of the debate surrounding high costs is addressed in the companion paper to this discussion (Lewin 200..). Given that science and technology education and training does justify some higher costs than most other curriculum areas the case for orientating its outcomes to those that have some utility in the labour market is strong.

Figure 1 summarises some of the arguments in favour of linking SET to labour markets. This maps various needs which should influence policy on science and technology, and consequentially policy on SET. Effective SET would seem essential to ensure access to different technologies and to allow process and product innovation that is domestically based. Without SET capability nationally, the ownership of proprietary technologies will become more and more concentrated in developed countries. The ability to choose and develop appropriate technologies, and the benefits of being amongst the first to develop and use them (first mover advantages), will both be diminished if SET is weak and unrelated to production and labour markets.

Figure 1 A Policy Framework Linking Science Education and Training to Labour Markets



Arguments against Links with Labour Markets

Four arguments are commonly used to suggest that science education should not be closely linked to labour markets.

First, predicting labour market demand, and its implications for SET, over all but the short term demand is unreliable. The techniques that were developed for manpower planning in the 1960s supposed that it was possible to project demand for different categories of labour in different sectors and link these to a qualification profile that would identify the numbers which would need to be trained to different levels in different specialisations. The problems with these methods are well known (Psacharopoulos and Woodhall 1985). They include the difficulties of building up realistic patterns of future demand from surveys of employers (who may over or under estimate growth as a result of failure to see beyond short term economic conditions); changes in the structure of the economy which are difficult to anticipate and may be exogenously determined (by, for example, falling prices for natural products as a result of the development of synthetics, increased competition arising from production in other countries with lower labour costs); and difficulties with the levels of substitutability in the labour force amongst those trained at different levels (graduates may be susbstituted by non-graduates when demand is high, qualification escallation may lead to graduates undertaking lower level jobs when demand for graduates is weak).

These criticisms imply that it is difficult to decide the nature of links with the labour market since its future form is unpredictable. However, the fact that micro-planning of labour force needs into the future is not possible overlooks two things. First, merely because precision is elusive this is not to say that inspired guesses are more helpful to investment. Iterative planning systems that make short-term projections that are constantly updated are a better guide to policy than pure speculation. They can elaborate labour market signals that can be used to tune education and training systems to provide more rather than less of what is in demand in terms of skills and competencies. Second, labour markets are changing. There is widespread agreement that patterns of employment in the modern sector of most economies are unlikely to provide either lifetime employment within a single organisation or jobs that depend on mono-skill specialisation. The implication is that education and training systems have to recognise the need to promote generic knowledge and skill which have wide application and can be flexibly deployed in a range of work situations. If this is so, the ability to plan science and technology education and training programmes linked to specific jobs becomes less important than the adoption of more strategic approach. The best guess seems to be that science and technology thinking skills and analytic competencies will remain in demand, though the nature of their application will change in unpredictable ways. Links with developments in the labour market that reflect the need for outcomes with generic application remain very attractive.

Second, it can be argued that SET is most relevant to labour markets in developed countries. If so expanding supply and improving quality will hasten brain drain. The rebuttal here is of two kinds. First, it is only partly true that SET is most relevant to developed country labour markets. To the extent that SET becomes globalised and is characterised by universal curriculum emphases derived from priorities established in developed countries, this may be true. However, at least some part of SET can be orientated towards the most pressing needs identified at a national level. If this is not seen as a priority domestically it is unlikely that any other groups will address such needs, e.g, for affordable technologies that improve basic sanitation, health care and meet demand for energy.

The second rebuttal is that even if it is true that a proportion of the most able migrate to greener pastures, there are two saving graces and one dilemma. First, migrants who remain culturally embedded in their mother country can remit substantial amounts of income generated elsewhere to fuel domestic growth and inward investment. They may become prime vectors in constructive technology transfer. Second, even if a proportion do migrate, many do not. They constitute the basis of domestic science and technology capability. The dilemma is that if the proposition is accepted that investment in SET serves mainly to promote the private returns to individuals who migrate and it should therefore be curtailed, then it is difficult to make sense of how domestic demand for SET qualified workers should be met. Dependence on expatriates is a solution that would seem to have some merit in small and dependent economies. As a development strategy for larger countries it has few attractions.

A third argument, advanced by some science educators and professional scientists, rests on a view that the conceptual integrity of science education is undermined by an emphasis on application and job related skills. In this view it is the logic of science, rather than the needs of the labour market, that should be the bedrock for the science curriculum. The architecture of science thinking, it is suggested, depends on a cumulative induction to science through a familiar diet of seminal experiments and theoretical reasoning that, at least in part, replicates the processes through which scientific understanding of natural phenomena developed. A corollary is that science is essentially a disciplinary based activity with characteristic modes of knowing and validation of knowledge that are not determined by application, which comes later if at all.

The counterpoint to this position is to note a number of things. There can be little argument that an understanding of science and any ability to apply thinking skills related to it does depend on acquisition of basic concepts in an orderly and systematic way. Such understanding is cumulative and hierarchical – it is necessary to understand some things before others can be comprehended. There is a logic to the subject and its development that is not monolithic, but it is certainly not arbitrary. The basic question would seem to be that, given this intellectual architecture, is it possible to develop SET programmes which use content and select thinking processes that are more rather than less relevant to occupations, livelihoods and life futures? And is it also appropriate to take as a starting point the conceptions and misconceptions that students and adults have of phenomena which are significant to them, rather than the abstract and practical concerns of previous generations of scientists located in a different socio-historic context?

The answer ought to be yes to both these observations. Most of the ideas that are contained in SET curricula have practical applications. If they do not, they should be questioned, not because they lack some other importance to the scientific community, but because time spent on ideas without utility may diminish the ability to act on the environment in developmentally constructive ways. It may also be difficult to engage adolescents in achieving mastery and sustain motivation unless starting points reside in the life world of learners. If SET is seen as abstract, imported, and lacking utility then it would not be surprising if students neglected its study. If content can be selected that is relevant to real world problems without degrading the need to develop rigorous enquiry methods, so much the better. If science education can be technologised to foreground the utility of its insights, what will be lost?

The ways in which scientific and technical knowledge is generated are changing. Gibbons (1998) identifies two modes of knowledge production. Mode 1 is characterised by hierarchical management of knowledge generation within physically located organisations, validation of new knowledge within restricted communities of professionals, specialisation, and problem definition grounded in fields of study and academic disciplines. Mode 2 is different. In this knowledge production is located close to application and driven by problems arising in the economic and social world rather than embedded in disciplines. Organisations have flat, task focused structures that allow flexible patterns of collaboration between research and development staff who are often not located in the same physical institution. Accountability, quality control and the validation of new knowledge is accomplished with reference to broadly based groups of stakeholders. Transdisciplinarity is common. Information and communication technology makes Mode 2 knowledge production much easier. Mode 2 challenges traditional patterns of the organisation of research and development, the associated learning and teaching, and the processes of knowledge validation and dissemination. Most real problems are cross disciplinary and do not fall neatly into one or other of the established disciplinary divisions of science. To the extent that this is true it strengthens the argument that SET should recognise and be more closely linked to application and the utility of the competencies it provides.

Fourth, there is a strong tradition amongst some educators that schooling is about the development of the whole individual and the nurturing of talents that all individuals posses. From this perspective most educational decisions should not be linked to pragmatic concerns about employable skills, or more generally analyses of national needs. That is someone else's problem, so this argument goes, to be resolved after students have left formal education. What matters most is the development of human potentials, providing these are generally regarded as constructive traits rather than anti social ones. Moreover, it is often noted, many if not most of those trained in science and technology do not engage in lifetime careers based centrally on the skills they have acquired. Hence to link SET to labour markets for qualified scientists and technologists is based on a fallacy – that most will use the skills they acquire in SET in employment.

This position does have some merit. However its consequences are unpredictable and offer few guidelines to decision making in educational systems in resource constrained countries. Clearly choices have to be made, especially where public investment is intended to serve both individual need and collective benefit. It can be argued that there is no necessary contradiction between concern for the development of individual talents to the fullest extent possible, and simultaneous recognition that collective benefits are one of the main reasons to publicly finance education systems. Strategic links to the labour market do not preclude other outcomes, nor unbalance the need to expose students to a range of means of knowing and experiencing which are not exclusively scientific.

A Labour Market Metaphor for Science Education

Some of the links that might exist between SET and the labour market can be illustrated by a metaphor. Production methods have been classified[1] as "Fordist" and "Post Fordist" (Kaplinsky 1995). Fordist systems are associated with automobile manufacture in the first part of the twentieth century. In these products are standardised to minimise variation in parts and assembly procedures, production is pre-planned to maximise efficiency and minimise labour costs, innovation in products and processes is intermittent, and quality is controlled after manufacture by specialised workers who inspect output for flaws. Post Fordist production differs in many ways and has been associated with the success of some manufacturing companies in the latter part of the twentieth century. In this production systems are designed to accommodate a wide range of variations in basic products which can be produced to meet consumer demand. Labour is regarded as an asset whose potential to contribute to production should be maximised, rather than an input to be minimised. The workforce at every level is encouraged to suggest innovations that will improve process and products. Quality control is distributed throughout the production process so that defects are rectified at the time they occur.

Figure 2 illustrates these differences.

Figure 2

A Metaphor for Science Education from the Labour Market

"Fordist" Model	"Post-Fordist"Model
standardised products	differentiated products
production "pushed"	demand led production
minimise labour	involve labour
individual and intermittent innovation	collective and continuous improvement
quality control at output	quality control at input

If SET is to prepare students to work in post Fordist organisations the question is what implications would it have for SET and links to labour markets? Some of the possibilities are explored in Lewin (1995b). Here they can be posed as questions.

First to what extent does SET allow differentiated products? The complexity and rates of change of modern labour markets suggest that a "one size fits all" policy on SET is undesirable. Many different needs can be envisaged for different groups in the labour force. Graduate engineers need different SET to those who work at the technician level. Achieving general scientific literacy in the labour force requires different curricula to those intended for specialised workers. We can suppose that SET policy should recognise a variety of outcomes for different groups and make different links to different parts of the labour market.

Second, is production pushed or demand led? Here the analogy with education is loose. However in planning SET there is a basic question of the extent to which the SET curriculum, and policy on streaming and tracking, is designed to be responsive to changing patterns of demand from students and employers, or is defined by the nature of science and more general decisions on the curriculum. Most SET curriculum development has been pushed rather than pulled. That is, curriculum developers usually start from good ideas about how to select content and teach SET, rather than from any analysis of what might constitute useful knowledge and skills for school leavers. Perhaps there should be a different balance.

Third, does SET minimise contributions from students or involve them in improving their own learning? Again the analogy is loose but useful. Many conventional SET programmes put students in the role of learner and assume that they have not much to contribute to the learning process. Active involvement of students, through invitations to suggest better ways of understanding science and technology from their perspective might pay dividends in motivation and in relevance.

Fourth, are students encouraged to acquire skills related to continuous improvement and co-operative rather than competitive problem solving? The answer is that for much SET this is not obviously so. SET curricula rarely allow much time and space for systematic development of skills for incremental improvement e.g. in experimental design. SET systems are also often characterised more by competition for grades than co-operation on the solution of collectively owned problems.

Fifth, what forms does quality control take? In most SET quality assurance is summative rather than formative, and it usually takes the form of end of course external assessment. SET students rarely evaluate their own work and that of peers. Neither are they often encouraged to assess their own performance self critically. Such forms of quality control seem more likely to encourage conformity rather than creativity, and devalue the development of internal standards, which can lead to greater achievement.

This analogy is presented as a tool for thought that can open up debate about ways in which SET might be linked to aspects of changing labour markets. The analogy should not be taken too literally. It is suggestive that links with competencies valued in labour markets goes beyond relevant content and includes skills which are consistent with some labour market practice.

Strategies for Linking Science Education to Labour Markets

What then might be some concrete strategies for closer links between science education and labour markets? Seven approaches could be productive.

First there is a need to identify learning outcomes for SET related to generic and transferable skills that are valued in labour markets. Some of these may be common across countries, but many may not be if labour markets vary widely. If there are to be links which relate SET to competencies which are rewarded, then this needs to be a first step.

Second, it is attractive to audit existing curriculum and encourage the inclusion of content and skills that are relevant to common occupations and livelihoods. This is often not a component of curriculum development. It does imply that systematic knowledge is acquired from the labour market as to what content and skills have utility.

Third, there is a case for technologising SET in ways that relate science concepts to application. Where there is a choice, content and concepts that have economic application should probably be chosen over those that do not. SET pedagogy could stress an emphasis on application in appropriate balance with underlying theoretical knowledge, without loosing its core concerns to develop scientific thinking and associated methods of enquiry.

Fourth, links between SET and the labour market can be enriched by involving employers and corporate sponsors in the curriculum development process for SET. This already happens to varying degrees. Educators may be unaware of recent developments in industry and the service sector which are related to SET. Dialogue should be continuous and could result in quality improvement and greater relevance of SET.

Fifth in many countries there is a need to increase awareness of the contribution different kinds of SET can make to the informal sector and to poverty alleviation. Introducing some elements of "street science" into the SET curriculum could have benefits for scientific literacy in general and informal sector workers in particular. SET designed to meet the science and technology based needs of the poorest might reduce the incidence of malnutrition and disease based on ignorance.

Sixth, it may be feasible to arrange work exposure and experience for teachers and older science students in some SET systems. This has benefits in establishing a dialogue between the SET system and employers. It should contribute directly to SET programmes and their outcomes.

Seventh, investment is needed in assessment strategies that reward conceptualization, analysis and application in SET. It remains the case that too much assessment promotes recall based learning, the disconnected accumulation of facts, and the decontextualised application of concepts. If SET is to be more closely linked to labour markets this should be reflected in how it is assessed.

Concluding Remarks

This paper has argued that the case for linking SET curricula and labour markets is convincing. Development is dependent on technologies that transform the economic and social conditions of life. SET provides a systematic basis for science based knowledge and skills to be acquired, applied and shared. The case has been made that such links need not undermine the conceptual integrity of SET curricula. They have the potential to increase relevance. Linking outcomes to the labour market can be both pro-poor and pro-growth. It does not preclude other valued outcomes. Curricula outcomes can be specified in terms of generic and transferable skills. Content can be selected which is more rather than less related to application and context.

There are many challenges that confront SET systems. Changing labour market needs and new modes of knowledge generation encourage the rethinking of traditional models of SET. So also do the information and communication technologies that open up many new avenues for delivering SET and linking its form to knowledge and skill which has utility and will contribute to development. Effective SET is central to improved living conditions of the poorest. Much of what needs to be known and applied to improve basic health, nutrition and food security is known, but often not by those who have the most to benefit from it. More generally economic development, which depends in part on the application of new and old technologies, is closely related to SET in many different ways. It can only make its full contribution if links with the labour market and different arenas of production are recognised and incorporated into the forms SET takes.

References

Asian Development Bank. 1997. *Emerging Asia: Changes and Challenges*. 1997. Manila.

Caillods, F., G. Gottelman-Duret, and K. Lewin. 1977. *Science Education and Development: Planning and Policy Issues at Secondary Level*. Oxford: Pergamon.

Gibbons, M. 1998. "Higher Education Relevance in the 21st Century". A paper prepared for the UNESCO World Conference on Higher Education Oct 5-9th. World Bank, Human Development Network, Washington, DC.

Kaplinsky, R. and A. Posthuma. 1994. *Easternisation: The Spread of Japanese Management Techniques to Developing Countries*. Ilford, England: Frank Cass.

Knight, J. B. and R. H. Sabot. 1990. *Education, productivity and inequality; the East African natural experiment*. New York: Oxford University Press.

Landes, D. 1998. *The Wealth and Poverty of Nations: Why Some are Rich and Some are Poor*. New York: W. W. Norton and Co.

Landes, D. 1969 *The Unbound Prometheus: Technological Change and Indiustrial Development in Western Europe from 1750 to the Present*. New York: W. W. Norton and Co.

Lewin K. M. 1995a. *Education and Development. The Issues and the Evidence*. London: DFID.

Lewin, K. M. 1995b. "Development Policy and Science Education in South Africa; Reflections on Post-Fordism and Praxis". *Comparative Education* 31, 2: 203-222.

Lewin, K. M. 1985. "Educational Aims; an International Perspective". In Torsten Husen, ed., *International Encyclopaedia of Education*. New York: Pergamon.

Mansell, R. and U. When. eds. 1998. *Konowledge Societies: Information Technology for Sustainable Development*. New York: Oxford University Press.

Psacharopoulos, G. and M. Woodhall. 1985. *Education for Development: An Analysis of Investment Choices*. New York: Oxford University Press.

Wood, A. and J. Mayer. 1999. *Africa's Export Structure in a Comparative Perspective Institute of Development Studies*. Sussex: University of Sussex.

Wood, A. and K. Berge. 1997. "Exporting Manufactures: Human Resources, Natural Resources and Trade Policy." *Journal of Development Studies* 34: 35-59.

Wood, A. and C. Ridao-Cano. 1999. "Skill, Trade and International Inequality". *Oxford Economic Papers* 51: 89-119

World Bank. 1993. *The East Asian Miracle: Economic Growth and Public Policy.* Washington, DC.

Titles in the Secondary Education Series

Ware, Sylvia, ed. 1999. "Science and Environment Education: Views from Developing Countries." Secondary Education Series. World Bank, Human Development Network, Education Group, Washington, DC.
Online version: http://www1.worldbank.org/education/scied/documents/Ware.pdf

Lewin, Keith M. 2000. "Mapping Science Education Policy in Developing Countries." Secondary Education Series. World Bank, Human Development Network, Education Group, Washington, DC.
Online version: http://www1.worldbank.org/education/scied/documents/Lewin-Mapping.pdf

Lewin, Keith M. 2000. "Linking Science Education to Labour Markets: Issues and Strategies." Secondary Education Series. World Bank, Human Development Network, Education Group, Washington, DC.
Online version: http://www1.worldbank.org/education/scied.documents/Lewin-Labor.pdf

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