PROSPECTS

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comparative education

ISSUE NUMBER NINETY-THREE

VIEWPOINTS/CONTROVERSIES

Interview with Jacques Delors

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ERRATUM

On page 839 of the English version of volume 2 of the *Prospects* series of 100 'Thinkers on education' (vol. XXIII, nos. 3/4, 1993) in the biographical note about Marie Eliou (Greece), the first line should read: 'Professor in the sociology of education and comparative education at the University of Athens.'

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EDITORIAL

In the afterword to No. 85-86 of *Prospects*—the first in the series of 100 'Thinkers on education' and the first also to be edited under the responsibility of the International Bureau of Education—we said that we had assumed a very demanding inheritance: that of maintaining intellectual rigour, respect for diversity and the ability to adapt to change. In over twenty years of existence, *Prospects* has been able to confront these three challenges by adopting an interdisciplinary approach, opening up its pages to researchers from all over the world and stimulating debate between different currents of thought. Keeping this tradition going, however, will require innovation.

Mankind at present is coping not so much with a circumstantial, passing crisis, but rather with the appearance of new forms of social, economic and political organization. The 'information society', 'post-capitalist society', 'post-industrial society' or 'third wave' are some of the expressions made popular in recent years by authors such as Jacques Delors, Peter Drucker and Alvin Toffler. Beyond the differences of approach and prognostication, all analysts agree that the new millennium will usher in profound changes in production methods, political organization, social structure and hence educational and cultural patterns. It is worth noting that, while the traditional type of revolutionary discourse has practically disappeared from the political arena, new pronouncements forecasting social and economic upheaval and modifying all dimensions of social and personal life now fill the pages and screens of the communication media. The bearers of these new revolutionary messages are not just political leaders representing the poor, the excluded and the exploited; on the contrary, they are individuals of very different political persuasions, familiar with state-of-the-art technologies and linked to the most modern sectors of the economy.

If one looks at the situation from the point of view of education and educators, one may appreciate the extent of the consensus that *knowledge and information are the most significant variables when it comes to explaining new forms of social and economic organization.* The notion has already become commonplace that the basic resources both for society and for individuals will consist of information, knowledge and the ability to produce and manage them. Education, understood as the activity through which knowledge is produced and distributed, thereby assumes an unprecedented degree of historic importance, in at least two different ways:

1. Firstly, from the political and social point of view, because *the struggle to appropriate the places where the most socially significant knowledge is produced and distributed will lie at the heart of future social conflict.* This means that educators, scientists, intellectuals and all those who are active in producing and distributing knowledge are bound to play a very important role in terms of both generating conflicts and solving them.
2. Secondly, from a specifically educational point of view, since the new conditions in which knowledge is produced and utilized raise the prospect that Hanna Arendt feared, namely an irretrievable split between knowledge and thought. Or, to put it in positive terms, *education's challenge is, now more than ever, to promote universally the abilities which enable each one of us to understand, to think and to speak about what we can do.* There is now an urgent, universal need to avoid falling into an unthinking dependence on the technical means of accumulating knowledge; instead we must promote the ability to operate them.[1]

These challenges raise many questions. No one is satisfied with the way education is currently responding to the requirements of a society in the throes of upheaval. Education is in need of new content, new institutional designs, new agreements between its different actors, and it also needs to identify the basic aspects which must remain, the fundamental values of the human condition which must be strengthened. Since there is no general agreement, no one is in a position to offer categorical answers to the questions raised by the new social and educational scenario. It therefore appears essential to rest our thinking on doubt and query, rather than on some claim to a single, categorical answer, as we are accustomed. The present circumstances, instead of extending the accepted range of uncertainty, are restricting it. Rejecting doubt is tantamount to encouraging the expansion of dichotomous visions, promising either a radiant destiny or total catastrophe. A society which is exposed to a constant, rapid pace of change needs citizens and institutions who are able to handle uncertainty without trying to stifle debate. Experimentation, which has been admitted so far only as a tool of scientific investigation, should be tried in both theoretical thinking and political practice.

Of all the problems and possibilities which are emerging in this period of upheaval, four aspects in particular are worth mentioning for their effects on future *Prospects* policy:

In the first place, the process of social change presently runs so deep that we have to reconsider basic issues regarding the purposes of education. Who is to assume responsibility for educating the new generations, and what cultural legacy, what values, what concept of man and society do we wish to pass on? The lack of discernment in vast segments of society and the short-sighted views underlying many decisions of political and economic leaders have revived the need to discuss basic questions. Philosophical thought is regaining the importance it once had.

Obviously, this is not meant in the sense of purely metaphysical conjecture, unconnected with operational aspects. On the contrary, the idea should be to situate technical and operational analyses within the overall framework of a concept which can give meaning to our behaviour. Any technical analysis failing to take account of this general framework is merely another version of technocratic thought. On the other hand, discussing the purposes of education while ignoring its operational aspects would not only be sterile from the point of view of action but abstract and unproductive from a theoretical point of view. One of *Prospects'* basic objectives will be to stimulate reflection on educational methods, institutional design and political strategies.

Secondly, as a result of the rapid pace of social change and the need to resolve the urgent and in many cases dramatic problems facing society, traditional relations between research, information and decision-making have been modified. Building democracy requires educating a citizen who is able to access information, to understand what is going on, who is capable of taking an active and conscious part in the proceedings. Access to information, in the broader sense of the term, is a crucial part of the process of building and strengthening democracy. The challenge consists therefore of designing instruments that can render educational information transparent. We have been accustomed until now to demand greater technical rationality in political decisions. Our efforts were aimed at improving the link between research and decision-making, facilitating the access of decision-makers to the results of research and to information systems. In the future, however, there will be a significant increase in the number of decision-makers, and therefore a greater need to train society as a whole to monitor the decisions taken at the highest political level. As a result, information systems and research results will take on a much more important political dimension than in the past. This leaves us facing a double challenge: that of introducing higher levels of technical rationality in political decision-making, as well as raising levels of political awareness of research objectives and the instruments of technical information.

Thirdly, it is worth noting that comparative education has recently acquired renewed significance. Now, much more than in the past, countries are observing the educational policies of other countries and comparing results. Successes and failures in terms of economic competitiveness are directly related to the amount of investment in education and in scientific and technological research, and to the results achieved with learning, and to specific forms of partnership between the actors in the educational process. But just as acutely, comparison is related to the strengthening of one's own cultural identity, and to the identification and enhancement of one's own values. One effect of the trend towards globalization, the supranational and the incorporation of the means of circulating information is the need both to reassert one's own values and to open up to others, to those that are different. As a means of analysis, comparative education in this respect has a great deal to offer, not only in terms of giving knowledge, but also as a means to promote tolerance, international understanding and respect for what is different.

In the fourth place, we must assume the consequences of the currently accepted principle whereby *education is the responsibility of all.* This principle is valid not only in terms of financing education, but also in terms of defining educational contents and policies. Education, now more than ever, requires an intellectual effort by everyone. This means that intellectuals and scientists in general, and not only the educators, pedagogues and researchers directly linked to the educational sciences, must assume responsibility for thinking about education for the present and for the future.

These brief preliminary thoughts may help to explain both the continuity of some of *Prospects'* features and its changes. The traditional sections of the review will be maintained. We shall, however, be giving more importance to discussions about the future; we shall systematically be calling on philosophers, economists, sociologists, anthropologists and political and intellectual leaders in general to express their views on education and its role in society. We shall also give greater importance to comparative aspects of education. Through a network of correspondents in different parts of the world, we shall do our best to reflect the existing diversity of situations and approaches to problems and we shall attempt to provide sustained support and circulation for the work of researchers in developing countries.

JUAN CARLOS TEDESCO

Note

1. Hanna Arendt, *The human condition,* Chicago, University of Chicago Press, 1958.

INTERVIEW WITH JACQUES DELORS

INTERVIEW WITH JACQUES DELORS

Jacques Delors, born in 1920 in Paris, has held several high offices in the French Government, including that of Minister of Economy and Finance. He was President of the Commission of the European Community from 1984 to 1994. It was due to his vast experience as an economist and specialist in social affairs that the Director-General of UNESCO called on him in 1993 to chair the International Commission on Education for the Twenty-First Century. The Committee's mandate is to review all the challenges which will have to be met by education in our changing world. This year the Commission will be submitting suggestions and recommendations which may 'serve as a programme of renewal and action for decision-makers and the most senior officials' of the Member States of UNESCO. Mr. Delors gives readers of Prospects his feelings and thoughts on these changes and on the important role which education can and must play in facing them.

PROSPECTS: What made you become interested in education, and why are you still very much so?

JACQUES DELORS: It is a question of character. Even when I was much younger I felt like teaching others as soon as I learned something. At the back of my mind there was always the thought that I could repeat the things I was learning, pass them on to others. At the outset it was therefore a matter of natural disposition that led me to become involved in education and training for more objective reasons in the course of my professional career.

PROSPECTS: But you are also interested in education as a political subject, not only from a personal point of view?

JD: Yes. Because education has its place in society and also its place in history.

PROSPECTS: Mr. Delors, a rash of labels have emerged in recent years to describe the society of the future. Some people have given it the tag of 'information society', others talk about the 'post-capitalist society', the 'third wave' or again the 'new Middle Ages'. What do you think about all those scenarios? Which of all those models would you rate the most promising and the most realistic?

JD: Many of the labels you refer to were picked to create a sensation and make books and newspapers sell. It is best to avoid over-generalizations when reflecting about the future of societies. I feel that developed societies are going through a major transformation common to all countries in the world, stemming from the growing interdependence of economies and social developments and also from globalization. There are also matters more specific to given countries, for instance to do with the search for purpose so that people can live in community, since a number of elements have conspired to make Western society less close-knit in the past twenty years. In the future, the search for the right balance between community and individual should be the central theme. But for that to happen, politics would have to stop being shaped by pure economism. The very trend of economic factors will oblige individuals and leaders to become more concerned about the whys and wherefores of living together, of the purpose of life, than they have been in the past. Making political debate boil down to mere economics—I am exaggerating a little, caricaturing, here—is untenable. A balance must be struck between an almost philosophical quest for new values and strictly economic concerns.

PROSPECTS: **Cohesion is a key topic in the debate on education, as schooling used to be such a vector of social cohesiveness. In the past, viewing education as something which bound society together was considered conservative, whilst the trend towards individualism, or the break with cohesion, was laid at the door of the revolutionary aspect of education or, shall we say, the part it plays in change. We are now reaching a somewhat paradoxical situation in which demand for cohesion is as strong as the call for forming individuals. Do you think that the future role of education from that standpoint ought to be to make the community more cohesive?**

JD: Historically, the eighteenth century marked the beginning of a growth era and the gradual domination of all facets of society by economics. This coincided with the emergence of schools of thought focused on the individual and personal development. The Century of Enlightenment then the French Revolution drew on that same inspiration. The individual became the meaning and subject of all social sciences and his development ranked above all other considerations. It was the individual who, through trade and production, formed society. At that time, however, people belonged to strong communities: the village, family, religion, parish and school. With the spread of urbanization and the latest changes in industrial societies, people can no longer identify themselves with such communities to the same extent that they used to. Individualism has therefore become more rife. The whole of classical economic society is based on the individual—and that thinking has definitely pervaded modern politics. Politicians obviously have to sell dreams and address other topics, but it is still economics which have pride of place. That being so, societies, at least our own, have the uneasy feeling that an imbalance is being created, that the position of the lone individual in the world cannot be tenable for long even though some people fill the void around them by frantic activity: working, watching television and the rest. It seems to me that citizens will become increasingly aware that the individual is also a social being and that work is not enough to fulfil the need for sociability. It is true that work is currently the number one factor of social integration—those who lose their jobs slide into depression and poverty and tend to become fringe elements—but work is not the one and only door to belonging to a community. Unfortunately, society has not yet produced any others, so that, if we are to move swiftly, that is the big problem for our tomorrows. Education must participate in this reconstruction of the social fabric. Teamwork must be taught in school as well as personal development, children need to be shown how to be attentive to others and to all the things around us, how to understand our surroundings—not only our economic but also our social and political environment, both national and world. It is that rather distressed individual, afraid of emptiness, who is at the root of the unease within our Western societies. Education can, partially, remedy that by enabling the individual to acquire knowledge and know-how which will be useful to him not only in his professional life but also in his life outside work.

PROSPECTS: **You have spoken about the factors of cohesion in times gone by: church, the community. There is another one: the nation . . .**

JD: I would be more cautious about the nation.

PROSPECTS: **We find that very interesting. After all, bringing people up to be citizens has been and still is linked to the idea of nationhood. What do you feel about that as globalization progresses?**

JD: I think that, in an economy which is turning worldwide and where everyone must be a player, there is no fallback position. Unless you accept becoming an aboriginal society! Therefore, in this open-world society, the ground rules first need to be laid down. I don't mean having a world government—that is still an impossibility. It was for that reason that I proposed the setting-up of an Economic Security Council as a forum where the heads of all the countries in the world could deal coherently with matters ranging from industrial production to trade, currencies, finance, ecology, and social and demographic trends. No such forum exists as yet, so that we are all thrown into this worldwide economy without any support and, I repeat, without any bearings. Accordingly, quite aside from any geopolitical considerations, the nation remains a recourse, an indispensable foothold, an irreplaceable element for fighting excessive individualism, against retreating into a shell, against lying in the lurch, for calling to involvement and citizenship. The nation remains a pertinent unit for analysis even though some nations have elected to become associated with others for the sake of efficiency, as in the case of the European Union. For all those reasons, it would be wrong to predict or even wish for the disappearance of nationhood.

PROSPECTS: **From the viewpoint of education, socialization as part of teaching loyalty to one's nation apparently used to be consistent with the commonly accep-**

ted idea of nation. Nowadays there is a sort of erosion of the nation concept, at least among some elites. Do you think that anything particular needs to be done about that in teaching the higher echelons?

JD: Yes. Senior politicians and managers often tend to talk in universal, global terms without giving a thought for the other social strata, thereby making themselves remote from the man in the street and sowing the seeds of imbalances and even catastrophes further down the road. It is therefore important for future managers and officials to realize that their fellows are lost in the extension of economic and social, even political, competition when they say: 'When I take a decision, I must bear in mind what is happening in Tokyo' or New York, or elsewhere. The leading ranks must be aware that they belong to a nation and that their nation must remain a factor in the life of the world, so that it will preserve individual identities, appeal to a sense of citizenship and serve as a home base and a benchmark.

PROSPECTS: **Training elites is a crucial aspect of education policy, in developed as well as in developing countries, since it is even claimed that part of the responsibilities for what happens in developing countries depend on elites.**

JD: I would agree with that.

PROSPECTS: **That brings us to higher education. Do you think that higher education should be a strategic priority? Based on your analysis, should there also be a balance between higher technical, vocational and classical education? How do you view the question of ethical training, or the forming of responsibility in the process of socialization of the elite?**

JD: Those who work on a world scale need outstanding and sophisticated training to be able to assume their vocational responsibilities, but these cannot be set apart from their responsibilities as citizens of the world and of their country. Therefore, all levels of higher education, including top specialist training, must leave room for the humanities in the fullest sense of the term, i.e. teaching people to understand themselves and others, to understand the world. I would however not go so far as to say that higher education must have top priority, since in a world becoming less workaday, with shorter working hours and more leisure time, the conventional opportunities for conviviality are not as great as they used to be and basic education must give each and every person the wherewithal to move undaunted in society, without sliding into anomie or aggressiveness. It must enable people to take themselves in hand and ward off any aggressiveness that could lead them to the fringe, for either economic, social, or psychological or personal reasons. Basic education is not only a major theme of reflection in developing countries, its importance and content for the richer countries of the world must also be stressed.

PROSPECTS: One tends to look at the two extremes of the education system: higher education for the elite and basic education for the common citizen. There is also a serious problem regarding secondary education, which used to establish a balance between those two extremes. What is happening now with secondary education: what role does it play?

JD: It is impossible to talk about this without observing that higher education has become so commonplace as to upset all the parameters. Tomorrow, one adolescent in two will perhaps go on to some form of higher education. Is that a good thing? That is another question. But demand for it is there, meaning that secondary education must be thought out differently, depending on whether it is to be the culmination of primary education or prepare pupils for inevitably diversified higher education. In fact more and more diversified, and which must keep its poles of excellence and its universities, as they are sources of research and innovation. Secondary education cannot therefore be considered an end in itself. Pupils either go on to university or branch into further or lifelong education. Secondary education should be rethought with those two facts in mind, whereas it was long considered the end of studies in most countries. And since there were no opportunities for life-long education, it encapsulated the learning of a whole lifetime. That era is over now. I would almost say that secondary education, besides the conventional disciplines of learning to memorize, think, analyze and write on subjects, ought to set itself the priority goal not only of making pupils 'learn to learn' but of instilling in them a genuine 'thirst for learning' by the time they leave. Society must organize itself with those changes in its sights. For instance, 18-year-old school-leavers should not be dubbed drop-outs, as their forebears who left school at the age of 14 used to be a couple of decades ago. We need to demonstrate that life-long education is a way of avoiding the chips being down at the tender age of 18, a way of opening prospects for all.

PROSPECTS: Tying what you have just said together with the other idea you put forward earlier on, that work is not the only means of social integration, it might be said that the question of primary, secondary and university education will become less meaningful, since those gradations matched the echelons in the job market. That begs the question of the institutional set-up of the education system. In that view, what are the respective roles of state and private education? There is often talk about partnership, mixed structures and so on. How do you see this?

JD: Traditions differ from one country to another. I however believe that the public sector must remain a key element in orienting education systems. The backbone. Especially from the angle of what I was saying about the nation. Who will carry a nation's values, keep its collective identities from oblivion and preserve its heritage if not its education system? Even if it does not assume the entire teaching function—it could not do so and anyway does not attempt to these days—it needs to be there as the bedrock.

PROSPECTS: **Looking at management style, state schools have drawn harsh criticism for their bureaucratic, rigid and uniformitarian side. Do you think that public education must change, bringing in different methods of operation in the new environment?**

JD: These must be a common corpus defined from the top. But the way that corpus is delivered may be adapted to suit the various pupil publics. A particular subject should not be taught the same way in middle-class schools as it is in schools where half the pupils are the children of immigrants. But the basic syllabus must be laid down. Beyond that, headmasters must obviously be left a certain amount of latitude for adapting to diverse situations while making allowance for the potential of children, not always in terms of a standard concept but sometimes in terms of artistic, physical and interpersonal strengths, etc. Those elements must be weighed up with discernment. In other words, the state education system must remain the reference, although it could be managed in a far more decentralized manner, far more attuned to the characteristics of the various pupil communities. Another thing: one of the elements of citizenship, and also one of the elements of common sense, is to realize that our well-being does not depend solely on how much money we have in our pockets: it also depends on the collective, or public, goods and services available to us. And education must fundamentally stay a collective service offered to all alike. At bottom, that is what makes a national collectivity. This entity provides a certain number of collective services to one and all on conditions to be determined. This is also part of a nation's unity.

PROSPECTS: **There has been a flight to the private sector in several countries even in education, including in developing countries. State education is going through a crisis because of poor wages, a lack of facilities and also policies to trim public-sector deficits by cutting back spending. And since some of the severest cutbacks have been in education, there are now calls for partnership in both financing and syllabus-setting. Therefore, if the public sector must define a common corpus, it must be common to both state and private education.**

JD: Of course. Education is a collective good. That does not mean that all forms of education must be dispensed through collective channels. Public education must remain the essential yardstick and be the driving force behind the system, so as to strengthen the notion of citizenship as well as that of the individual or person. It follows that, since I am not talking about an exclusive monopoly, there is room for private schools, but they must comply with the rules which represent what a nation wants its children to know or to learn. From then on there can be all manner of teaching approaches imaginable: in-service, alternating, within the private sector for part of lifelong education and even within social facilities. One learns by joining a charitable association or being involved in cultural work. This opening-up of educational possibilities should not lead to the baby being thrown out with the bath water and saying: 'Why keep a common system at all?' It is said that public education systems are bureaucratic. But one can always conduct a successful experiment—or two or three or four—on the side. If the entire system were private, would it not become bureaucratic in its turn? Or anarchic? Or fail to meet the minimum standards which the nation intended to set and teach to everyone? That is the bottom line. This is proof enough that a solely professional approach to education would lead up a blind alley which would be dangerous both for public well-being and for personal development. The two systems must therefore be kept in some equilibrium. True, some education systems have been straying too far away from economic actuality in the name of putative humanism. But I would warn against going too far in the other direction, now that economism will be becoming a less dominant force in political life and society than it has been over the past fifty years. I am speaking as an economist who realizes the value of things: the cost of a recession and the benefits of a stable currency, a trade surplus and a competitive economy. But life cannot be reduced to such simple terms. And, moreover, does not being economically successful call for a good understanding of oneself and of one's fellows, a certain ability for valuation, an openness of mind and a capacity for listening without which there is no way of winning through in a career? So let's be careful. These days, the assertion I have just made is all the more meaningful for the fact that post-industrial society—let us give it that label—will be one in which work will no longer be the only factor of social integration and individuals will have to be taught how to behave in situations in life which are not simply centred on leisure either. They will, for example, have to learn to cope with a year out of a stable job and elect to use that time for on-going education, doing voluntary work in an association or some such opportunity. Each person will have to be able to order his or her time in a world where the conventional stages, the traditional trilogy, of school, work and retirement will no longer be germane. The longer that trilogy is perpetuated, the more disruptive of society it will be. Just think of all those people who have been pensioned off at the age of 55. From one day to the next they have stopped counting in the economic scheme of things. They have continued to cost, since they draw pensions, but they no longer count. Physical resources, creative forces, professional and social skills have been sloughed off as waste. That is not consistent with a society in which technological progress is shortening required working hours at a sustainable rapid pace. Today's employee will spend 70,000 hours of his life at work: that will be 40,000 hours in fifteen years' time—a considerable drop in a few short years—due to an acceleration of the trend which has always been caused by technological progress. We are currently set on innovation, but we are blinding ourselves to the consequences whichtechnological progress will have on society, on the individual and on the workplace—and thereby on the education system.

PROSPECTS: **That is an interesting point, because if work becomes not the only key factor of social insertion, if money is not to be the only objective in life, then the only way out is to revert to some aspects of traditional society in which neither the economy nor work were the only elements of social integration.**

JD: This is a classic instance of history turning full circle. At one stage the hardest academic question to answer is, what is immutable and what can change? And obviously, focusing solely on change while disregarding everything that has become a set part of a social system is a major intellectual and political mistake.

PROSPECTS: **But education is to a certain extent also made up of educators. By asking 'What must education do?' we are actually asking 'What must educators do?' Have educators really been prepared to take on all the new challenges such as educating for creativity, teamwork, problem-solving and social cohesiveness?**

JD: It is clear what balance could be built into primary-school curricula, but where things get complicated is in secondary schooling. Teachers themselves should team together so as to be able to overcome the problems of teaching, of giving courses in a real-life situation to a distinct set of pupils. And it would be wrong to add to curricula and initiate courses without a concerted reflection by teachers on the way in which groups of thirty or forty pupils develop and on how they perceive improvements and shortcomings. I believe that teachers ought to learn how to work as a team and not say 'I give a very good course and polish it every year'. No: they have a broader responsibility which is not simply that of a headmaster. That is why I am for teamwork among secondary-school-teachers, so that school equips the young personally for facing adult life.

PROSPECTS: **The teachers of the twenty-first century are today's youngsters who have chosen to go into teaching. And several studies have shown that, after a whole decade of sliding standards and pay in the profession, particularly in developing countries, today's young who plan to be teachers are not the highest achievers of their generation. Recruits are being drawn from intellectually poor social classes without much hope for the future. For prospective policies, it would seem crucial to waste no time in launching an incentive, or pre-recruitment, policy and find out how to attract the highest achievers into teaching.**

JD: For that, society must first be weaned off money. If money dominates, if business executives claim that they must make at least X amount of francs or Y amount of francs otherwise their standing and effectiveness would be jeopardized, if money is the benchmark of social hierarchy, we will never solve the teacher problem. Can money be the only measure for ranking one of the finest professions in the world, in which a person is entrusted with passing on to others what mankind has learned about itself and educating the younger generations? Such a money-grubbing society seals the fate of its education system by its very existence. It would never have been possible, as was the case back in the 1920s and the 1930s, for university professors to enjoy the same high rank in industrialized societies as solicitors and barristers. Secondary-school-teachers also had a certain standing, and primary-school-teachers were also held in the utmost respect. If the only criterion is now how much you earn, then there is no answer. No solution. And the same will go for civil servants. Politically it must be made plain that the money standard is not the one and only recognized hierarchy: those of knowledge, usefulness to society and public esteem also exist. For that reason I have always thought that, whenever any problem with teachers had to be addressed—including any lag in their real incomes—it was best to start by explaining to them as the minister in charge of education how important teaching was, what a key position teachers held in society; how vital they were. In my opinion any report on education must contain some words in praise of the various teaching professions, and not only because it is the 'done thing', otherwise we are sunk. I am not talking about special cases and I don't want to give an excuse for doing nothing about salaries and material conditions, but if a nation's political leaders fail to highlight what teachers represent for society and social progress, then all efforts will come to naught, since teachers will feel like outcasts, not having been awarded the noble status belonging to their true role in society.

PROSPECTS: **The thing which may now utterly change teaching is technology, the welter of new information paths which are making some teachers believe that they might be replaced by an integrated services network that would assume the role of learning technology. How do you see the relation between an information society and the role of school and teachers?**

JD: I will reply to that question from the aspect you have referred to: i.e. what will the new technologies bring to the education system? Immense pools of knowledge accessible to each and every person. However, they will not make it feasible to replace a living teacher by a computer or television screen. We will always need teachers maintaining contact with students. Technology will have its uses: after all, if an excellent mathematics or history course is available with a very high pedagogical content, what should stop a teacher showing it to his pupils on a screen? But he will have to be there afterwards for explanations. Of course, some 10 per cent of all young have studied without the help of a teacher. I myself studied for six years whilst holding a job, without meeting any teachers. But not everybody can manage to do that and it is not the best way of studying.

PROSPECTS: **We have talked about citizenship, teachers, the relation between education and work, the role of the State, the training of the elite and the problems of primary and secondary schooling. To end with, there remains the question 'Who will do all this; who will be the social agent capable of fostering an education policy along those lines?'**

JD: We are living at a time when society is being driven by various forces into changing more rapidly than political thinking is. If developments are left to happen by themselves, the price will be disorder, strains, social exclusion and more generally an undermining of cohesion. Changes must be thought out. I do not mean rigorously charted, because we are talking about human life with all its random variables. But changes must be thought out. That implies knowing a society well and having working assumptions on its future trends, on which to pattern the grounding to be given to all the men and women making up that society so that they may make the most of the changes in their environment and even in their minds. The task is therefore highly political: I would go so far as to say that it is a matter of political philosophy. How to enable a society to unshackle itself from economism, technological progress and globalization? These things are the order of the day, so how can they be taken on board, mastered, and how should the man in the street be given the means to handle them? I believe that if we have a general concept, it can be referred to for fine-tuning educational policy. I did say fine-tuning, not completely overturning, since education is as old as life itself and, I repeat, there already exists the tradition of handing down what we know, what we have learned and what we have thought about. It is by reference to that heritage that an education system can be adapted. We touched on that subject when talking about higher and basic education, the fringe of society and poverty, even in rich societies. Incidentally, contrary to what many political leaders claim, it is not a matter of making people decide between the status quo and change, since change is already at work within society. Society lives with it more or less well. No, the thing is to arm people so that they can come to grips with change individually and as a group. Aside from making adjustments to the education system, that also entails reviewing land-development policies, town planning and public relationships, etc. But education is still the key element, since it gives every boy and girl the means to develop as a person and live in society.

PROSPECTS: **You are said to be highly voluntaristic about taking action, lending great importance to the will of agents rather than to social and economic determinism.**

JD: Yes, but I repeat: most societies have their own conception of politics. Looking at how society lives, at its environment, I can see that everything is in a state of flux, on the move. No one knows in which direction. But it is by taking careful note of shifts that a policy can be put together—the blanket policy of the city within which education policy has a high profile since nothing can replace what will be given as a right and which will make it feasible for individuals to live as they want, untrammelled, taking advantage of the equality of opportunity, etc.

PROSPECTS: **One last question. You are a man of politics in the broadest sense of the term. What themes would you like educators to clarify; which currently hazy aspects needing answers would you wish researchers and educators to delve into for the future?**

JD: First and foremost the teacher/student relationship. How can we work on this relationship in such a way that the teacher remains the master, in the noblest meaning of the term, and the student treats him as such. The respect of knowledge, of learning, of experience: that is probably the essential point for me. And it is quite clear that adolescents now entering secondary school think they know everything because urbanization, city living with its show, its television and its entertainment give them the impression that they are knowledgeable, that they are grown-up. Either that or they get bored with all these things they know and cannot imagine what use they will be to them later on. Therefore it is indeed the teacher/student relationship which is the nub of the matter. And everything we have talked about has some connection to that, including how societies treat their teachers. And, as I said, not just in material terms.

SCIENCE TEACHING FOR SUSTAINABLE DEVELOPMENT

INTRODUCTION:

NEW CULTURAL AND ETHICAL FRAMES OF REFERENCE

André Giordan

The acquisition of a scientific and technological culture is an essential factor in the economic competitiveness and the industrial influence of a society, but it is more than just that.

The twofold increase of scientific knowledge in less than ten years and the swift development of modern technologies are tending to undermine our ethical and cultural values. The new challenges with which we are faced—the environment, AIDS and other epidemics, uncontrolled population increase, economic crisis, etc.—call for new frames of reference.

The emergence of new methods of procreation and of genetic engineering challenge us in our private or social lives. Can we do just anything? What are acceptable limits? What are the risks for the individual and for the human species? Who is to decide—the scientists, the doctors, ethical committees, the politicians or the public?

The development of communication and data-processing technologies, such as on-line information systems, computers, robotics and the application of biotechnologies, are changing our methods of production and our consumer habits. They are challenging the principles and foundations of traditional economics. The concept of work is being transformed.

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These new resources are simultaneously generating increased leisure time and millions of unemployed. How do we want the situation to evolve in the future? For the benefit of whom? To do what?

Bringing scientists out of their ivory towers

With so much at stake, scientific, technological and medical knowledge cannot remain confined to the laboratories. It must be shared with the bulk of the population.

These changes are obliging us to conduct searching reviews and to call for new intellectual tools. New values and new mechanisms for the regulation of society are being envisaged.

This is the context in which a sharing of scientific and technological culture should be envisaged. Scientific culture, contributing as it does to the changing of our perception of the world, is an integral part of our culture. Destined to play a decisive role, it is becoming a source of invention and creativeness for the years ahead. In addition to the pleasure of learning, it can offer everyone opportunities for enlightened consideration of technological issues and the future development of society.

It is democracy itself which is in question. No democracy can actually work without discussion concerning the type of development desired. Until now, however, there has been no wide discussion involving the majority of the population concerning health systems and methods, the choices with regard to energy or consumption, transport, birth (contraception, procreation, etc.) or death (euthanasia), or the kinds of research to which importance should be attached.

Moreover, for want of scientific culture, no discussion makes sense now, because the questions at issue are so closely bound up with science and technology. What criteria should be adopted? How should the experts be called to account? How should the repercussions of an industry be considered? How should thought be given to the new implications of a research project? The scientists and technocrats cannot claim to speak for the general public when such social issues are at stake.

Reconciling science and society

Introducing a scientific and technological culture presupposes a fundamental change in the relations of individuals with science and technology. Although science and technology are a powerful driving force in economic and social development and are considerably altering our daily lives, the gap between science, technology and society is tending to widen.

Most people continue to think that these disciplines do not concern them and that they are the concern of specialists. Scientists, engineers and doctors, for their part, have to produce specialized knowledge faster and faster, in increasingly limited fields, to remain competitive. Their work does not incite them to wonder about the why or the how of the consequences of their studies or about the implications of what they are doing.

Science and technology are thus becoming a subject of controversy. When called to account they give rise to further questions, provoke opposition and even arouse anxiety. The development of anti-science movements and the rise of irrationality and fundamentalism, facilitated by television, are evidence of this.

The reconciling of science and society, of classical culture and scientific culture, is therefore one of the challenges of our time.[1] For that, however, researchers must come out of their ivory towers.

Here, scientists, engineers and doctors bear a large measure of responsibility, since they must partake in dialogue with the public. Beyond the confines of their specializations they can no longer be content with thinking or acting in a sectoral fashion; they must set themselves the task of grasping the full complexity of the human, environmental and cultural systems within which they move.

They should be both vigilant watchers, who give the alarm and do preventive work for the society which subsidizes them, and pathfinders who discover, elucidate and assess the possibilities and risks involved.

At this level, their chief task is not to proclaim with certainty but to explain in detail the issues, the choices and the theories, and to consider the possible scenarios. In these circumstances they can provide information that will enable the decision-maker and the general public to make up their minds.

An integrated cultural policy

This transformation of relations between science and society, however, is not a matter for specialists alone. The school has its rightful place provided that it can carry out a far-reaching reform. When young people are asked if they are interested in science at school, they nearly always say no. In Europe, it is true, we have to admit that pupils are often put off by science subjects.[2] Their curiosity wanes as they go on to higher classes.

Science teaching, its syllabuses and its methods frequently fail because they do not sufficiently take into consideration the pleasure young people derive from discovering. Science and technology are not subjects that arouse enthusiasm, such as sports or rock music. The sciences are frightening because they are used too much as a means of selection. In addition, current teaching methods in the sciences make them rather repellent from the outset, demanding as they do memorization, an abstruse vocabulary and endless mathematical formulae.

As long as science is taught in this way it will be impossible to give the bulk of the population as much scientific knowledge as possible and to put that knowledge into perspective. What is more, this prematurely abstract science teaching, unrelated to everyday life, jeopardizes the quality of the culture to be inculcated.

Luckily, many teachers have grappled with the problem. Many innovations are being introduced and the results are spectacular.[3]

Today, however, school is no longer the only place where people learn. To establish a culture the whole community has to be mobilized. The media—the press and television in particular—have a role to play, provided they no longer confine themselves to the topical and the spectacular.

Museums and new associations for the sharing of knowledge need to be established. They too have a vital role to play. Furthermore, an integrated approach to science and technology is needed.[4] These facilities are not there to take over the people's task of understanding; what they must to do is put people in a position to ask themselves questions and to understand.

Notes

1. Philosophical and scientific knowledge remained closely bound up together for over two millennia. Only two centuries ago did those bonds begin to loosen, to the detriment of all concerned.
2. Technology is unfortunately still excluded from the curricula, except in the case of vocational education. It involves highly formative thought processes.
3. For further information, see: G. De Vecchi and A. Giordan, *L'enseignement scientifique, comment faire pour que « ça marche »?* [How to make scientific education work], Nice, France, Z'Editions, 1989; A. Giordan and C. Souchon, *Une éducation pour l'environnement* [Environmental education], Nice, France, Z'Editions, 1991; and A. Giordan and G. De Vecchi, *Les origines du savoir* [The origins of knowledge], Lausanne, Delachaux, 1987.
4. Bridging the gap between science and society means giving the human and social sciences more weight by introducing the history, the teaching and the epistemology of the sciences into courses habitually dominated by 'hard' sciences, and making sciences subordinate to philosophical and anthropological perspectives.

THE SCIENCE, TECHNOLOGIES AND SOCIETY (STS) MOVEMENT AND THE TEACHING OF SCIENCE

Gérard Fourez

This introduction to the movements known as *Science, Technologies and Society (STS)* and *Scientific and Technological Literacy (STL)* begins with a review of two historical currents in scientific thought: that of project sciences and that of the so-called fundamental sciences. It discusses their place in education in general, and in the social and historic context of science teaching in particular.

This article then goes on to analyse the overall aims—economic, political, social and human—of the STS and STL movements, describing some of their teaching objectives, for which it proposes an operational translation into a series of capabilities and skills. It demonstrates the place occupied in these movements by epistemology, the history of science and the multidisciplinary approach. Finally, it lays emphasis on the inevitable ideological dimension involved in any teaching of science.

The notion of Science, Technology and Society (STS), sometimes presented as Scientific and Technological Literacy (STL),[1] stems from a movement in the sociological sense of the term, i.e. an assembly of opinions and actions having certain features in common and reflecting changes in society.[2] This movement affects the teaching of science, but that is not all. If it is to be understood, it is important at the outset to briefly consider the history of the links between science and society.

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The socio-historical background and the teaching of science

At the beginning of the nineteenth century, scientific thinking and the communities that shaped it split into two parts: first, the sciences concerned with action, such as medicine, engineering, architecture, etc. and, secondly, those sciences that were henceforth called 'pure', 'fundamental', or 'single disciplines'. It was often said of the third category that these disciplines were focused solely on 'knowledge', although certain contemporary epistemological views dispute this separation of knowledge and action. It would be more appropriate to characterize these two elements by saying that one is concerned with projects made explicit in their social context while the other veils its projects behind a scientific image, seen as being faithful to a well-defined paradigm (as the epistemologists say, the fundamental sciences are 'standardized' more by a paradigm giving them an appearance of being universal than by socially identifiable projects).[3]

The two currents have entered educational institutions. The action-oriented sciences found their ecological 'niche' in the faculties of medicine and the schools of engineering, later to be known as colleges of 'applied science', while the others have mainly flourished in faculties of science. The development of science courses in secondary education has drawn inspiration from the approach of the second current. Although the educational function lives, moves and has its being in a human and social universe that is as complex as that of doctors or engineers, the sciences have begun to be taught according to the standards of the specialists.[4] For a long time, primary education was little involved in this dichotomy of scientific thinking, but one can perceive a trend whereby the primary teaching of science is increasingly 'disciplinarized'. In any event, the fact that technology—as well as the social side of science—is usually missing from general secondary education courses that are supposed to be fundamental can be regarded as a sociological trait that must be taken into account.

The STS movement is often held up as a response to the fact that the conventional teaching of science has run out of steam. For some decades now, in the industrialized countries, as elsewhere, voices have been raised expressing concern at how unsuccessful science teaching has been. The students seem unprepared for using science in ordinary life and, what is worse, seem to have a growing aversion to it. It is increasingly accepted that the conventional teaching of science is now in crisis, if not facing total failure.[5] This, for example, was the view of Morgan in his report to the Forum of UNESCO's Project 2000+, which quotes studies mentioning 'the lack of relevance of the conventional model of scientific education for many students'.[6]

This crisis is manifest as a lack of interest in scientific careers, a development that could endanger the scientific and economic development of the industrialized countries. Developing countries are affected by this problem in a quite different way, since they take the view that they cannot afford the luxury of research that is too 'disinterested'. They consequently want science to assist their growth.

It is possible, without being too rigid about it, to distinguish two currents in the STS movement, even though, because of their informal nature, situations and outlooks vary from one country or one culture to another; 'representatives' of the two currents may frequently find themselves side by side at meetings or conferences; or the two currents may even be present in the same person.

The first current follows the tradition whereby science brings understanding which can lead humanity towards a better future. According to this attitude, science should not remain in its ivory tower but place itself at the service of 'progress'. For example, this movement rejects science teaching that has become too theoretical and remote from daily life. Science classes should, for example, train young people to have more respect for nature and to be able to interact with it. This current places considerable importance on the links between scientific results and ethical or political attitudes. It is embraced by many teachers who have concerns for ecology or public health; indeed it sometimes produces an amalgam of scientific results and ethical standards that surprises the ethics specialists.[7] This way of looking at things—which is not always free of scientific ideology[8]—primarily attracts those science teachers and scientists who believe it is high time this type of education was recast. Their central concern stems from an acute awareness of the importance of the scientific approach, and may be regarded as an extension of the age of 'Enlightenment'. Moreover, this awareness is probably not very distant from the concerns of the 1960s, that optimistic period when man went to the moon and when people were generally persuaded that science and technology would shortly eliminate deprivation.

The second current is rooted more in an analysis of society with social and economic components. It makes deliberate use of the literacy metaphor. It is based on the notion that, just as it has been necessary for nearly a century now to be able to read and write to make one's way in society, so a certain kind of knowledge is necessary today in order to get by in a world that is steeped in science and technology. This current is that of scientific and technical literacy. From this point of view, science is not regarded as an end in itself, but rather as an intermediate step that has become necessary to life in society. Modern science is no longer seen as producing absolute, universal and unchanging truths, but rather as a particular way of tackling understanding which has become established in the West, has proved there to be highly effective and has imposed itself—or has been imposed—on the rest of the world. This is the outlook which led to the publication in the United Kingdom of David Layton's book *Technology's challenge to science education*[9] and—to some extent—in the United States of *Science for all Americans*[10] and *Benchmarks for science literacy,* and many other contributions. It was also this outlook which predominated at the Forum of UNESCO's Project 2000+ in the summer of 1993 in Paris. This current, although it attaches great importance to science and technology, primarily envisages action in society. Its appearance is perhaps due in part to the problems of managing major technologies, their accidents, pollution and the continuation of deprivation, all of which have led many people to discard the technocratic optimism which predominated twenty years ago.[11]

The general aims of STL

The aims of this movement most frequently correspond to a number of economic and political, social, and humanist approaches. They were drawn together by Aikenhead, who believes that STS education seeks 'to produce wiser decision-makers, more responsible citizens, a more democratic nation, a more humanist corpus of scientists and engineers, or even a greater number of scientists and engineers (particularly amongst women)'.[12]

The first line of approach involves economic and political objectives. Scientists, economists and technologists agree that unless the entire population is involved in the scientific and technical cultures, the developed economies are liable to encounter difficulties, while the developing countries will find it hard to 'take off'.[13] In this context, STL must be related to the movements which, at least since the eighteenth century, tie education to the increase in the wealth and well-being of nations.

The social line of approach follows the idea that, without a scientific and technological culture, democratic systems are more and more vulnerable to technocracy. For example, how is it possible to formulate a democratic policy with regard to AIDS or drugs—which necessitates public discussion—if the public cannot understand what it is all about?[14] According to this view, STL should inform the public to a level allowing them to understand the technical decisions and hence enabling them to exercise democratic control. It then becomes a question of distributing powers throughout society or, at any rate, reaching a situation where the public does not feel too impotent with regard to science and technology and what they involve.

The third line of approach is more personalized and cultural. Its aim is to enable every human being to join in our scientific and technical culture, to communicate with other people in it about the world in which we live, to maintain a degree of independence within it as well as experiencing some pleasure at being there. This involves a number of dimensions.

To begin with there is the historical dimension, in order to understand how science and technology emerged in human history and formed part of it. Next, an epistemological dimension, to grasp how science is constructed and how scientists work; an aesthetic dimension, to appreciate the way in which a theory or a machine is adapted to a situation; a bodily dimension, for appreciating one's body in conjunction with tools as the intelligent locus of our human presence; a communications dimension, for grasping the way in which science and technology contribute to constructing a world view that is more or less common and communicable; a pragmatic dimension, to determine what information we need in order to feed ourselves properly, to drive our car, to protect ourselves from disease, and so on. All this suggests a link with the ethical debate, in so far as science offers us a representation of the possibilities of our action. All this forms part of our culture, since science and technology are part of the representation of our history.[15]

The educational objectives of STL

The general aims of the STS movement having been identified, it is now possible to set out its more precise aims, which can be translated into educational objectives. Thus one might mention various factors that should enable people to negotiate situations: e.g. the autonomy of the individual, a personal component, communication with others, a cultural, social, ethical and theoretical component, and some degree of environmental control, an economic component. Objectives such as these can be made manifest by a few standard examples capable of turning them into action: understanding the concept of infection or evolution, knowing the reasons why frozen food cannot be refrozen once thawed, familiarity with a computer programme, the intelligent use of a fax machine, how to handle a diesel engine in the cold of the mountains, or thinking about the origin of the universe.

Some scientific and technological knowledge favours the autonomy of individuals. Once capable of grasping concrete situations, they can negotiate reasonable and rational decisions when confronted with a series of problematical situations. In this way, for example, an individual may break free from functioning on the basis of set formulae, which implies the requirement of a behaviour pattern or attitude, making him dependent and causing him to lose some of his potential for autonomy.[16] This objective of autonomy can serve as a criterion for judging the importance of knowledge by separating out knowledge which increases our dependence on experts or specialists from knowledge which enables the individual to establish, with those experts, a more partnership-based and egalitarian relationship.

It is also possible to evaluate the importance of knowledge in terms of the way in which it enables us to communicate with others about our life situations. This is probably the strength of theorization. Building up and defining a theory is tantamount in fact to giving oneself words, concepts and sharable representational structures that permit us to tell others what we are doing. Unlike requirements or set formulae which leave no room for dialogue or negotiation, a theory is a shared mediation in human communications; it is thus at the root of partnership dialogue and therefore essential to the ethical and/or political debate.

Finally, possessing an understanding of the world invariably implies know-how and the ability to act. It is the way in which knowledge generates individual and social capabilities which gives meaning to theorization. As pointed out several decades ago, science is intrinsically linked to a form of power, which does not necessarily mean the domination of other people. One might therefore consider

> somebody as scientifically and technically literate when his understanding gives him a degree of autonomy (the possibility of negotiating his decisions in the face of natural or social constraints), a certain capacity for communication (finding the way of 'saying') and a certain control and assumption of responsibility, faced with concrete situations (such as infection, deep frozen food, the computer, a fax machine, a diesel engine, and so on).[17]

Feasible operational objectives for STL

Once the importance of pursuing the objectives has been accepted, they must then be rendered operational. Different ways of doing this have been adopted, mainly in the English-speaking countries.[18] This has been done primarily according to discipline content, by describing the content to be understood. Here we propose a series of objectives[19] related to basic capabilities in conjunction with scientific and technical practice.[20]

Making good use of specialists: being capable of consulting experts such as doctors, garage mechanics, computer specialists or, as far as the government is concerned, economists or engineers; and striking a balance between dependency on the expert's knowledge and exercising a healthy critical outlook; judging when it may be useful to seek a second opinion or when it is wise to contravene the requirements, being able to translate what the specialists say, moving from one context to another and discerning any 'abuses of knowledge'.

Making proper use of black boxes, i.e., those intellectual representations or machines[21] that one uses without considering it necessary to look into the way they work: for example employing ideas about viruses in talking of infection, or ideas about the electron in talking of electric currents or using the microwave or the iron, without being concerned about their structure. The objective is to learn to recognize when it is worthwhile opening or not opening a black box, i.e. studying the theory appropriate to certain circumstances, such as how aspirin works in order to dose it intelligently. Nobody can be regarded as scientifically and technologically literate if they are unable rationally to decide whether to open black boxes or to leave them closed.[22]

The proper use of simple models (islands of rationality).[23] This means knowing how to build simple but relevant models for oneself in a particular context of action or communication, such as modelling a fuse which has blown. Whereas 'single discipline' or 'fundamental' scientists tend to regard a simple model as imperfect, engineers or doctors will consider that the value of a model should always be related to the context and project in which it is considered. The simplicity of a model is not always a weakness, it can even be a strength. Students must learn that 'doing science' means acquiring a simplified and basic representation of the world's complexity, and that it is essential to the scientific approach to be able to call a halt to the complexification of models. Also, the teaching of technologies cannot be restricted to the transmission of simple formulae: it is a matter of acquiring a model, i.e., a 'theory', of technology, of its aims, of its operation and of the social organization it implies.

Inventing interdisciplinary models or islands of rationality: since no single discipline is sufficient for dealing adequately with a concrete problem, students must be taught methodically how to construct interdisciplinary models. Thus the insulation of a house will necessitate a representation of the problem involving many precise kinds of knowledge, from physics to law, not forgetting biology, economics, aesthetics, or the experience of users, which is precise even though not socially standardized. This objective, in order to become operational, perhaps more than others will require acquisition of a theory of the rigour of interdisciplinary work.[24]

The proper use of metaphors (comparisons): contrary to the view held by certain teachers, who claim to use only so-called 'scientific' concepts, scientific creativity involves using metaphors. Indeed, scientific concepts are usually no more than metaphors which have become 'seasoned' and standardized through use.[25] For example, the concepts of cell or system are highly typical in this connection.[26] It is a matter of teaching young people how to rediscover the strength and fertility of ways of expression that compare one phenomenon with another.

Access to standardized scientific and technological languages and models: this objective is the same as that of conventional science courses. In fact, in order to communicate in our society, it is not enough to be able to invent representations of situations. One must also know how to use the models that have become standardized and accepted and which are known as scientific results. This is why, in order to be scientifically and technically literate, everyone needs to acquire a whole series of concepts, models and theories in the form that they have received from the history of science and the historically constituted scientific disciplines. These would include, for example, mass, weight, evolution, the cell, chemical reactions, electric charge, etc.[27] Course curricula often tend to be limited to these standardized items. They occasionally neglect to take account of the fact that these models, knowledge of which is necessary if one is to get ahead in our society, are seen as dogmatic because they are imposed on students as irrelevant abstractions, taken out of their context of invention and use. But while standardization is too often a source of stagnation, it is also good practice[28] and must be learned.

The proper use of translations: STL requires the capability to move a question from one perspective to another, from one theoretical framework to another, from the paradigm of one discipline to another. Thus, a 'tummy-ache' will be translated by the doctor into 'stomach pain', and then possibly retranslated as 'gastric hyperacidity' or exhaustion, another possible translation. Scientific and technological literacy requires one to know how to get a foothold in the network of translations involved in using science and technology.

The ability to negotiate, not only with people, but also with objects and standards: an adequate theoretical representation can allow somebody to find an acceptable compromise between contradictory standards or formulae, for example between the cost of thermal insulation and its effectiveness, between precision and the time necessary to carry out an operation, or between various precautions against a possible infection and so on. In order to negotiate in this way with people, objects or techniques, it is important to know how to represent what is possible, to create a certain theorization of the situation, an island of rationality.

The ability to link knowledge and decisions: if one is able to construct an island of rationality suitable for a particular situation, one can then take technical, ethical or political decisions by calling on the understanding assembled in this way. People may be regarded as employing STL when they are able to make specific use of their understanding of scientific or technological approaches and results. Here science has a practical role to play as a representation of the possibilities of human actions.

The ability to distinguish between technical, ethical and political discussions: this ability is necessary to be able to make adequate use of theoretical models in decision-making. The term 'technical discussions' is used to denote those conversations relating to the ways and means involved in an action. These discussions in no way concern the issues of our existence which, on the contrary, will be involved in the ethical discussions that question the aims of our action and the values involved. A political discussion marks the search for compromise between groups that do not necessarily share the same aims or values. It is important to know what part scientific knowledge can play in the different types of discussion.

Epistemology, history, interdisciplinarity

In so far as it seeks to highlight the link between science and the social and personal universe, STS education is not easily compatible with just any type of epistemology, notably with those that place little importance on the subject constructing the knowledge. On the contrary, it goes along very well with constructivist and especially socio-constructivist epistemologies[29] which emphasize that science is a human product, structured by humans for humans and according to their plans. This kind of epistemology permits a critical dimension demonstrating that science does not reveal the world's truth but rather produces singular representations of our possible actions, allowing us to communicate and act. These representations are appropriate in varying degrees to the contexts and projects into which they are introduced.

In this kind of context, the history of science plays a special role.[30] In fact it is not possible to assimilate a scientific notion unless one has some idea of the context which justified its invention.[31] It is essential to understand why and for whom it was invented. In addition, the historical perspective draws attention to the fact that a notion does not belong to the nature of things but is a human invention intended to permit communication and action in a precise context.

Finally, as soon as an attempt is made to insert scientific practice into the social fabric and its technological components, single-discipline approaches become inadequate. However, although the principle of interdisciplinarity is routinely accepted, its implementation is not trouble-free. Teachers have often been 'warped' by a resolutely monodisciplinary education and by an epistemology (ideology?) which led them to value only disciplinary work. Some research and training is probably necessary to ensure that science teaching gives the disciplines and the knowledge standardized by their paradigms the importance they deserve, while rigorously exercising interdisciplinarity.[32] This no doubt implies a better understanding of the operation of the criteria and standards applied to knowledge. On the one hand, the paradigms, in the Kuhnian sense, govern the production of disciplinary and standardized knowledge; on the other hand, the projects and their background constitute the main criteria in the construction of project science and interdisciplinary approaches.

The ideological dimension of science teaching

In seeking to link science and society, the STS movement became aware of the ideological expressions conveyed by the teaching of science: e.g. representations of the world, one of whose functions is to motivate people, legitimate their practices and promote the cohesion of different groups, even if this means clouding the origin and the social effects of these expressions.

A fairly conventional viewpoint holds that science teaching is only scientific, with no ideological content. However, science courses do involve non-neutral images of the world. Thus there is a wide difference between classes that declare: 'We shall now prove that the distinction between insulating materials and conducting materials is a fact' and those that state: 'We shall now see that it can sometimes be useful to distinguish between conducting and insulating materials'. Although the 'scientific' content of the course is the same, the representation of the science put forward will be very different.

The statement: 'We shall now learn how to observe nature' does not have the same meaning as: 'We shall now learn the observation techniques used by a biologist in the field'. The same applies when the following is given as an example in an arithmetic class: 'With 200 French francs, it is possible to buy a steak, a CD and a cinema ticket' or: 'With 50 French francs, it is possible to buy 2 kilos of bread, 10 kilos of potatoes and a bag of coal'.

These examples, which we shall not analyse here,[33] demonstrate that science classes do not only convey a neutral scientific outlook. On the contrary, faced with students whose critical faculty is much less awakened with regard to these questions than to those in a philosophy or history class, the teachers, who are themselves frequently unaware of this aspect of their actions, transmit a particular idea of science, the world and society. At least one part of the STS current believes it is important that teachers should be aware of this phenomenon. Not in order to try—which would be illusory—to teach an ideology-free course, but to try to balance what they transmit and perhaps to avoid passing on, through their scientific teaching, an ideological content which would be unacceptable according to their own ethics.

Conclusion

The teaching of science, as it is widely practised today, often still believes itself capable of passing on virtually absolute knowledge remote from the tensions of society. The STS and STL movements, for their part, do not share this belief. Notwithstanding this, their conception of science teaching does not generate any less enthusiasm.

On the contrary, these movements regard science as a human product and full of humanity, and claim, with varied and highly differentiated points of view, that science can be understood as a space in which we create—with a great deal of imagination—representations of what is open to our potential for action. Science teaching thus becomes a human place, showing the features of a special history, related to the decisions we take; it is a place of logicality and communication attached to our projects and a place that conveys particular views of the world and of society. In brief, it is a place in which the future of our existence, our culture and our social life is played out.

Notes

1. For an in-depth analysis of these prospects and of all the factors outlined in this article, see Fourez, 1994.
2. A description of this movement in the United States can be found in Waks, 1986, p. 177-86. This includes the manifesto of the National Science Teachers Association (NSTA) on the subject.
3. Bensaude and Stengers, 1992, p. 125-206, on the subject of the fundamental sciences, speak of 'science of the teachers': this is knowledge produced and standardized by a highly stable profession rather than by entrepreneurs whose eyes are fixed on the results to be achieved.
4. In this article I often use the terms 'standard' or 'standardized', but not in any pejorative sense. In fact, although standardization can often lead to stagnation, we must remember that without it no communication, precision or communicable experience or technique are possible.
5. Reports about such a crisis are abundant in the English-speaking world. For a fairly elaborate review of this crisis in the French-speaking world, see *Le monde de l'éducation,* n° 1778, 1991. There it is stated, inter alia, that the French education system is producing too few engineers. Elsewhere, with regard to the teaching of mathematics, the report of the Belgian Danblon committee complains, for example, that not enough mathematicians are being trained to teach the subject. With regard to what is happening in the United States, see for example the contribution by Waks, 1986. See also: Rutherford, 1990, and American Association for the Advancement of Science, Project 2001, 1993. For the French-speaking world, we would mention Giordan, 1989, p. 29: 'It is impossible to go on much longer imposing overloaded school curricula, the content of which is sometimes incoherent and often not properly thought out with regard to current needs'.
6. Morgan, 1993. Similar, scattered judgements can be found in the various reports of this UNESCO meeting in July 1993.

7. In this regard, see Fourez, 1993.
8. The term 'scientism' is applied to a representation of knowledge which tends to place science on an absolute footing and consider it outside meaningful contexts. Scientism is a belief that the universality of science is not a socio-historical phenomenon to be explained as such but in fact a universality of law. This concept has resulted in the Western world imposing, as a beneficial outcome of universal civilization, that which can rather be regarded as a particular—but highly effective—way of representing the world. For a sympathetic yet acerbic analysis of scientism, see Stengers, 1993.
9. Open University Press, Buckingham, 1993.
10. Even though one can criticize this book for an attitude which in the end is highly technocratic and which in many aspects reflects a scientific ideology.
11. A technocratic approach is one which claims to avoid negotiations about decision-making by leaving them to technicians who apparently act in a less 'political' and more 'neutral' manner by having regard only to scientific and technical results. For a critical review of technocratic ideologies, see Fourez, 1992, p. 178-90.
12. Aikenhead, 1992.
13. Thus the International Council of Scientific Unions, in setting out its position at the United Nations Conference (UNCSTD), affirmed that long-term and continuous growth was impossible unless the funds invested in science and technology were matched by those allocated to additional educational programmes aimed at training scientists and technologists and at improving the scientific literacy of the entire population (Stoltman, 1993). A similar point of view was put forward in the famous report *A nation at risk,* produced in the 1980s at the beginning of the Reagan administration. Scientists and educators whom nobody suspected of intellectual laxism had reached the point of wondering, to their own surprise, whether the lack of culture and scientific literacy was not a threat to the West (see the relevant report by Holton, 1986).
14. In connection with this link between science and politics, see the little book by Stengers & Ralet, 1991.
15. If someone is to find pleasure—of the aesthetic, bodily, communication or other kind—in science, a degree of training is needed, just as it is for appreciating a picture by Van Gogh or a symphony by Mozart. Some people have an education or social conditioning such that they experience no pleasure in contemplating the satisfactory operation of a theory or the suitability of a tool for a precise task.
16. It should be noted, however, that not all dependency or loss of autonomy should be regarded as a bad thing: useful and valuable requirements do exist. Nor is 'autonomy' synonymous with individualism or egotism.
17. Fourez, 1994. We may note that this 'literacy' is not only related to the factual side of situations, but also to one's affective, social, ethical and cultural life.
18. For example: Rutherford, 1990, or American Association for the Advancement of Science, 1993; or again, Department of Education and Science and the Secretary of State for Wales, 1988.
19. It is to be noted that access to such objectives will require educational research outside the principles that are currently most fashionable.
20. This is a summary of what we propose in Fourez, 1994, p. 52-64.
21. Or more often 'mixed' in both the representational and material senses: in fact, a technology or drugs are not only material objects but a combination of the material and the representational, to which a social aspect must always be added: see Latour, 1989 or Fourez, 1994, Chapter 5.

22. This question can be related to that of prerequisites: to get ahead in our techno-scientific world, it is essential to learn how sometimes to use concepts without worrying about certain 'prerequisites', nevertheless dear to the heart of the specialist.
23. This theoretical idea which I have proposed (for example in Fourez, 1994, p. 57-59) uses the metaphor of the island in an ocean of ignorance and designates a theoretical representation appropriate to an envisaged context and project which make it possible to communicate and act in their regard, thus introducing rationality into communication and action. Martinand spoke of 'islands of rationality to be conquered . ... in other words, structures of intelligibility or systems of standards not granted but reconstructed' (Giordan, Martinand & Raichvarg, 1992).
24. This is what I tried to do in Chapter 5 of Fourez, 1994, p. 87-118.
25. See Stengers et al., 1987.
26. See Mathy & Fourez, 1991.
27. The American Association for the Advancement of Science, 1993, gave a selection of such contents regarded as essential to STL.
28. Indeed, the phenomenon of 'modern sciences' cannot be understood without considering the fact that they are, in one way or another, enterprises for standardizing knowledge. It is thus—and at this cost—that they achieve a certain universality (see Fourez, 1992).
29. Constructivist epistemologies are those which, notably following Piaget, stress the role of the subject in the production of knowledge (see Larochelle & Bednarz, 1994, p. 5-19, or von Glasersfeld, 1994). The term 'socio-constructivism' will be preferred when, beyond the psychological subject, there is also pressure to find room for the negotiations and social interests which structure knowledge (see Fourez, 1992). With regard to constructivism, teaching and the representations of students, see the work of Desautels and Larochelle in, for example, Larochelle & Desautels, 1992. See also Aikenhead, Ryan & Desautels, 1989.
30. With regard to this role, see Fourez, 1994, p. 161-72, and Mathy & Fourez, 1991. Also see Martinand, 1993, p. 89-100.
31. And not 'discovery' as is often said. The epistemologies and conventional history have too great a tendency to believe that a concept or theoretical model was there to be 'discovered', while in fact it was invented, just as the wheel or the internal combustion engine were invented. See Fourez, 1992, p. 49-73, or Stengers, 1993.
32. For a methodology of interdisciplinarity, see Fourez, 1994, Chapter V, p. 87-113.
33. This kind of analysis can be found in Fourez, 1985, 1988, 1989, 1992, or in Mathy & Fourez, 1991.

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THE AIMS OF SCIENTIFIC EDUCATION IN THE COMING DECADES

Victor Host

Since the Second World War, our technical, biological and social environment has changed considerably; man has taken a prodigious step forward in his knowledge and in his mastery of nature. This achievement is due to a great extent to the development of basic and applied research, which in some countries takes up over two per cent of the gross domestic product. A knowledge-based social system has become an essential power factor, even more so than the possession of raw materials and energy sources. It is not easy to distinguish between the two types of research, since nowadays a large part of basic research stems from practical problems, particularly of a military kind. Conversely, many discoveries of the basic sciences are immediately used in technical applications (e.g. lasers). Only scientific research, that is, the study of deterministic relations between objects, independent of human undertakings, will be considered here.

In many cases, change has taken the form of a considerable improvement in material well-being, as symbolized by the motor car, as well as better health, the eradication of certain diseases, longer life expectancy, and declining hunger despite an increase in the population. On the other hand, the all-out drive for production stimulated only by the desire for profit or power has brought about an uneven distribution of wealth, the rapid depletion of natural resources in terms of raw materials and energy, increasingly widespread pollution, the threat of nuclear war, the greenhouse effect and other climatic changes, so that the very survival of the human species is at risk.

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This places research before two requirements: on the one hand, it has to support the development effort, because a large part of the world's population still expects it. The needs of a rapidly growing world population have to be met and the developed countries are evolving new qualitative needs to replace the accumulation of unnecessary processes. On the other hand, research must provide a critical analysis of decision-makers' plans for changes in life-styles, and devise instruments which can predict the long-term effects of man's impact on nature and on himself, without being influenced by reactionary and apocalyptic theories.

In addition to these two functions, there are two others which have appeared as a result of the rapid transformation of our environment, especially following the development of communication techniques: how to make democracy more attractive at a time when technical advances are strengthening the power of hierarchies and dispersing human activity in networks and computer hypertext without any sense of responsible awareness; and how to achieve permeability between cultures, when, despite the loss of tradition and the apparent media-induced trend towards greater uniformity, there is instead an exacerbation of violence fostered by ideologies which seek justification in the culture of individual social groups?

Scientific culture and the mastery of nature

In the last fifty years, the quantitative growth of scientific research has brought about profound changes in its organization, its procedures and its output. At the beginning of the century, the laboratory was a workshop where a creative, scrupulous craftsman handled his few instruments with the help of a handful of disciples. His relations with the scientific community were almost personal; his bibliographic searches were direct and limited, and the accounts of his research appeared in a few specialized journals, giving rise sometimes to lively discussions, but leading, through successive approximations, to knowledge recognized as a step closer to the truth. Now, sociologists of scientific activity (such as Bruno Latour) describe the laboratory on the contrary as a kind of factory, where machines have taken over all the repetitive tasks of manipulation and data processing and work is carried out by complex, often hierarchical teams of researchers.

Documentary research has become automated and concentrates on recent data, ignoring the slow maturing of ideas which prepares the change of paradigms. Whence a faster output of knowledge and fierce competition between laboratories to be first with a discovery. The time saved on practical work is partly wasted on the hunt for budgets and on administrative tasks.

The knowledge produced has to be constantly reshaped because it is so quickly refuted; it is often presented in the form of models, which serve as the basis for many developments, but the experimental meaning of which remains a mystery to the non-initiated. Some sociologists even reduce scientific work to a form of social activity like any other, leading to the output of statements arising from a social consensus founded on immediate utility, unconnected with nature or reality.

The contrast between these two descriptions is such that they hardly appear to apply to the same discipline. In fact, they could be said to be caricatures of two different aspects of one and the same reality. The image of the craftsman scientist and the naive hagiography which goes with it give a schematic representation of the epistemological aspects of scientific activity, from the definition of the scientific problem to the work of refutation which restricts the concept. The factory-laboratory, on the other hand, conveys the complexity of instrumental and intellectual techniques which embody the experimental approach. In the eyes of the novice, the object and the meaning of the process reside precisely in the construction of instruments, the examination of trajectories, the analysis of graphs, the processing of number sequences and the distribution of tasks.

Progressive and therefore sufficiently early scientific training is needed if scientific practices are to be used and understood in their present social setting on the basis of elementary or simplified situations, such as work in teaching laboratories, the analysis of documents on the history of science, or participation in local research activities.

The problem of recruiting qualified researchers, which was acute in the United States after the Second World War, has not disappeared completely. The disaffection on the part of many students, especially young girls, for scientific studies is due to many reasons. Some are related to the objectives of scientific research, such as their pursuit of means of destruction, or the excessive tendency to concentrate on reductionist activities. Others are related to the methods used to teach science in schools; owing to an excessively strict approach, material is presented with mathematical tools which are not fully mastered by the students, while the updating of curricula gives rise to endless changes. Not enough demands are made on the students' creativity and only the barest hint is given of the connection with the problems of everyday life.

A laboratory's performance depends not only on the quality of its researchers, but also on its team spirit. Technicians are responsible for building and maintaining installations, and for looking after their cultures and breeds in very strict conditions, and they sometimes detect significant clues which can further their research. On the other hand, months of work can be lost because a file is badly kept or collections poorly preserved. An abstract, elitist type of scientific education is not enough to allow research to develop properly. It needs a much broader public equipped with scientific and technical training, which can provide the sort of environment where research problems can mature on the basis of views exchanged on practical problems. For example, the world of animal farming in England in the eighteenth century prepared people's minds to face the question of evolution. The growth of research in developing countries will depend on a successful interaction between research training and a much broader scientific literacy founded on a converging approach to the same problems.

To gain credibility, many human activities try to appear scientific. Most of the time, they involve only misleading advertising or ideological statements which are easy to debunk. It may happen, however, that a scientific claim is made in good faith to dress up theories claiming to be based on experience, such as astrology or many doctrines in the medical field, like homeopathy. For these theories, analogy constitutes a sufficient criterion of truth; for instance, a correspondence with the movements of stars, or cures of like by like. The theory does not go any further than formulating hypotheses. It is not concerned with failures, as indicated by the saying: 'the exception confirms the rule', whereas a fundamental aspect of a scientific proposition is that it must be based on the refutation of a statement (Popper's falsification) before the concept's range of validity can be determined or it can be reformulated.

Scientific activities and integrating man in nature

A protective approach to nature stems, in the first place, from an awareness of the danger which the frantic exploitation of natural resources and the accelerating transformation of their living environment represent for human beings. The photographs taken of the earth from artificial satellites have contributed to the rapid change in the way we see our planet: instead of a mine of unlimited resources, it is beginning to appear more as a finite object where life is maintained through a system of fragile balances.

A protective approach to nature starts from the analysis of practical situations. This may call attention to and expose certain variables which were either unknown or voluntarily overlooked, as in the case, for instance, of a plan for reallocating land or for building a motorway, or else it may help assess the significance of individual forms of behaviour if they become generalized, as in the case of pollution or energy waste. In order to arrive at a conclusion, it is often necessary to apply traditional scientific notions in complex situations far removed from the elementary structures of school learning, a skill which is often neglected because schools are not open to the environment. At the same time, a vigilant and open approach to experience has to be developed, equally far removed from the suicidal attitude of the partisans of *laissez-faire* and from idyllic conservationist attitudes which ignore the prodigious transformations that have occurred in our living environment since the Stone Age. A second level approach consists in applying specific scientific concepts to the study of systems, especially ecology. This can extend the space/time perspective to the scale of the biosphere as a means of identifying matter and energy cycles and of determining man's impact on populations or on certain climatic factors, such as the greenhouse effect. Here too, scientific debate does not lead to rigid rules, but to cautious action which will evolve in step with the broadening of knowledge and with the changes brought about by human activities.

In all the above cases, respect for nature is anthropocentric, insofar as nature is seen as serving mankind, without any significance of its own. The notion of respect for nature, however, can take on a very different meaning. Instead of exploiting nature, man can see himself as a participant, coexisting in harmony with the universe. This idyllic vision of man merging with nature, so dear to the Romantics, impressed many German naturalists at that time. It now reappears in the Gaïa project, which extends the notion of life to the whole earth and professes an animistic view of the universe.

It is also possible to give a scientific basis to the notion of respect for nature, provided that the strictly reductionist attitude to science is abandoned and prospection is admitted as part of the scientific process. In this sense, man should define himself not as an object bounded by his own body but rather as a node in a network of short or long relations which extend indefinitely though space and time.

Any living being is much richer and more complex than we imagine at present. Instead of pouncing on it to reduce it to a state of preparations and extracts, according to the dictates of science, it should first be contemplated through the eyes of the artist, taking pleasure in seeing it live, in observing it with curiosity and surprise, even though we know that it is destined to be eaten or destroyed. This is not just a simple affective fixation alternating with sadistic treatment of living beings, but more a kind of rational attitude on the part of the artist-scientist which is often a prelude to discovery. For the same reasons, it is preferable to avoid as far as possible the disappearance of species, so long as the inventory of living species is not complete and not enough is known about ecological balances.

More generally speaking, the pursuit of social objectives should not stifle the enjoyable dimension of scientific education. An understanding of the laws which try to give the simplest and most coherent explanation of matter — the physicists' dream — and a growing awareness of the history of the universe, of the earth and of life, are potent driving forces in our scientific culture. They help to bring down the barriers between disciplines and raise fundamental issues which guided the steps of early scientific research. Otherwise, we might as well just have fun watching Steven Spielberg's film 'Jurassic Park'.

Scientific education as an instrument of mediation between cultures

To a great extent, societies are held together by a culture, a set of representations which sanctions imposed rules and finds expression in the rights and traditions which maintain social cohesion. At the same time, this culture conceals the material causes of conflict and the biological origins of aggressiveness in order to justify wars and the subjection of other men. The rapid change of living environment and the growth of the media are at present debilitating many societies by dissolving traditional values. Culture also produces a certain superficial uniformity in societies, which does not reduce the causes of antagonism, but instead diversifies methods of destruction, with a choice of scientific wars, civil wars, terrorism, massacres, etc.

Scientific culture has been blamed for perpetuating this violence for quite opposing reasons. Some accuse it of trying to take the place of religions, which are deemed to be mere sources of fanaticism; it would propose instead a rational basis for morality by posing as the only source of certainties common to all men.

But 'scientism' has failed, if one is to judge by its decline in recent decades. Whenever it has been systematically imposed, it has completely distorted scientific thought, as clearly illustrated by the report on the Lysenko affair or the school biology textbook decreed by the Nazi rulers.

Others accuse scientific thought of engendering destructive scepticism on account of its fundamental postulate, namely that truth is not expressed in the form of changeless statements, but in successive approximations, which continue indefinitely. This postulate applies only within the field of scientific activities. Its limitations are not perceived by researchers, whose thoughts are concentrated on mastering their specialty and identifying the powers they gain thereby. The vacuum resulting from the lack of any thought regarding the meaning of their activity drives some minds aggressively to seek integration.

In fact, scientific training can contribute greatly towards open communication between cultures, provided that it takes the latter's messages and values seriously. It can ease the transition from the fragile stage of tolerated tolerance and passive peaceful coexistence to the discovery of convergent tendencies and the appreciation of differences. Scientific culture gives shape to activities and methods which should be part of any human experience, such as the importance given to a creative attitude regulated by social confrontation, or the importance given to listening to other people, or the readiness to refashion one's own ideas. These attitudes will not necessarily be transferred into the area of ethical values and conflicts, but they do provide some kind of reference and safety framework and facilitate the development of those who recognize the need for such requirements. Science also provides us with objective knowledge concerning man, society and nature. It gives us a more objective image of the origins and evolution of man and nature, and strip away social representations from outdated props. In some fields, such as human reproduction, science does not impose any specific solution, but it helps to explain the probable consequences of man's intervention. It also plays a great role in exposing the racist hysteria which often lurks insidiously in cultures until it breaks forth in periods of crisis. Efforts to rationalize social representations can bring to light convergences between systems which are in appearance impermeable.

Scientific education as an aid to democracy

For over a century, many educational reformers have tried to supplement literacy with scientific initiation of the future citizen as a way to ensure the proper functioning of democratic institutions and to give a scientific tone to the hygienic practices imposed. For instance, Jules Ferry in France advocated early scientific education in order to shield the future citizen from the influence of the notables. In a democracy, decisions have to be taken after a public debate, which is open to all and free of domination, whether explicit or concealed by the media. This is the method of direct democracy, which still survives in the palaver, where the master of ceremonies gives the floor to each member of the group and, in successive rounds, gradually achieves unanimity through negotiation.

In fact, this ideal has become increasingly difficult to achieve owing to the growing complexity of the technical society, both from the point of view of its material facilities and from that of its hierarchical organization resting on a scale of abilities. Those who hold power control all the factors needed for decisions: information and procedures for processing it, scientific knowledge and methods of calculation to give it practical effect, and control of the means of communication and possibly the means of conditioning it. They must exercise these powers through the experts who work for them. The dialogue between the expert and the base operator is distorted by the hierarchy of skills. The expert masters all the above-mentioned skills and implements them at the highest level. His mode of expression is confusingly complex in the vocabulary and especially the type of reasoning he uses, which calls on calculation procedures based on models and probability. And yet, however strict he may be within his own field of specialization, the expert is often wrong, because he may completely overlook variables which either lie outside his own discipline or are not quantifiable.

The operator, on the other hand, who may detect unnoticed clues because he is in touch with practical situations, either may not be listened to or may not be able to take advantage of his findings because he cannot master some of the aspects of experimental thought; he tends to reason by analogy based on a simple comparison of general situations, and to interpret probability reasoning as a lack of knowledge. The discussion then often appears as an attempt at conditioning and the operator remains most of the time excluded from the decision-making process.

The shortcomings of traditional scientific training, already referred to above, partly account for this situation, insofar as the late, elitist character of such education is due to the strictness of the mathematical approach. Vulgarizations for the public at large are not considered to be scientific. By distinguishing between steps of scientific ability, it becomes easier to give scientific education a progressive character. The highest level—research—is identified as the mastery of all facets of experimental method within a finite field, in other words the ability to formulate problems starting from the present state of science, to go beyond traditional procedures and to invent whatever instrumental practices are required to solve the problem. This mastery of techniques is restricted to the particular discipline and creates a confined area of restricted rationality.

The intermediate step consists in the ability to reinvest knowledge once acquired, by being able to identify the situations where it applies, by mastering cognitive or instrumental techniques to implement it, and by being ready to follow the development of knowledge in the particular discipline concerned, which is often broader than that of the researcher.

The lowest step is that of honest vulgarization. It does not require mastery of experimental techniques or the instrumental practices of the discipline. Competence is identified as the ability to translate the same statement into different languages and to recognize analogies, and by the predominance of iconic thought over symbolic thought. These characteristics reflect the mode of presentation most often used by the media. Moreover, owing to its broad range, it provides a means of integrating the discontinuous, isolated areas of rationality of the other two steps and facilitates closer contact between parts of knowledge from different disciplines. The progression of scientific training is not a matter of successive access to the three steps, but more of their relative importance and their progressive complexity.

Introducing early scientific education implies taking into account the level of cognitive development of the students. Whence the need to postulate different presentations of the same concept, such as reproduction or molecules. Far from being a better-than-nothing solution, this advance through successive levels of formulation can meet a positive need, insofar as it provides a means of determining the best formulation for any particular social practice; the operational definition of breathing will not be the same for a sportsman, a fish breeder or a biochemist. Moreover, it would seem that scientific activity by the young child encourages his cognitive development and is conducive to the functional learning of writing and mathematics.

The role of scientific education as an instrument of communication is particularly important in education for health, for instance for the effectiveness of the dialogue between the patient and his doctor, which differentiates human medicine from veterinary practice. The objective, precise information provided by the patient will partly determine the accuracy of the diagnosis and the type of treatment administered. Modern medicine requires a critical and positive awareness on the part of the patient, who is faced with the diversity of specialists and sometimes with automated practices, and who is sometimes the only one able to make sense out of diverging data and contradictory propositions.

THE PURPOSES AND METHODS OF TECHNOLOGICAL EDUCATION ON THE THRESHOLD OF THE TWENTY-FIRST CENTURY

Jean-Louis Martinand

In some countries technological education is a reality (Deforge, 1993; Eggleston, 1992) but in others it is still only a project. Its immediate, primary characteristic is that it is connected with technology, and hence to very changeable components of the operation and dynamics of our societies.

The question of education relating to technical matters is an issue everywhere and it is in this sense that the use of the word 'technology' has spread. In France, the emergence of it as a subject in general, compulsory education can be situated in the 1960s (Centre international d'études pédagogiques, 1992). It came later in the United Kingdom, where concerns were, however, very similar to those in France at the same time (Black & Harrison, 1985).

The world picture of technological education is varied and changeable. Constant thought should be given to the problems it presents and this article seeks to make a contribution to this process.

We will focus on four themes: the aims, the object and the approaches, and the thresholds that must be crossed in order to have genuine technological education.

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The aims

What motivations underlie the political will to establish and develop technological education? Politicians often ascribe three aims to it: (a) to develop an attitude favourable to contemporary industry, business and technology; (b) to help people discover what they want to do at school and, through a deeper understanding of economic activity, what occupation they wish to take up, while revealing skills and inclinations; and (c) to combat failure at school through activities in which all pupils can succeed.

These aims are certainly legitimate, but the last of them is very largely mistaken. Because of the way in which subjects at school are structured and function, one particular subject cannot prevent failure in the rest. It would even be fair to say that a subject must be selective or lose its value. But while technological education cannot be a special weapon in the fight against failure at school, it must, nevertheless, like all subjects, confront the things in itself which produce difference and transform it into failure.

These three aims provide a framework for technological education and outline the conditions needed to justify its existence. They are, however, insufficient to ensure that it will be provided. For this to happen, another aim seems essential and must be examined with particular attention. This concerns the understanding and practical control of the contemporary world, which is deeply imbued with technology. This last aim raises the important problem of technical education and its social and educational status. It is essential to know what the character and place of technical education will be in order to plan school activities. This also implies a reformulation since, in reality, the problem is that of the relationship between technical and general education.

In contemporary society, there are technical subcultures connected with occupations, domestic tasks and leisure activities, which lead to the formation of very strong affinity groups. At the same time, it is fair to say that, side by side, there is also a massive lack of scientific knowledge. But the technical subcultures are socially undervalued and 'culturally' marginalized. Can they be used as a basis on which to develop technological education?

In Europe, the major option for technological education at school could be to include technical culture as a component of general culture, which would clearly have to be reshaped to be able to admit technical culture. It is not therefore a question of integrating the technical subcultures based on occupational skills or hobbies such as do-it-yourself.

A solution has to be found to some fundamental problems concerning the status of technical skills and the relationship between culture and technical skill, in schools and in society as a whole. In this connection, a whole series of facts needs to be examined. The subcultures mentioned above are often based on highly developed technical skills. Thus there are deep-rooted adolescent technical cultures for mopeds, computers, etc.

At the same time, a field or a subject may be rejected by the recognized general culture because of its technical nature which is, nevertheless, the precondition of its existence. This 'technical nature' is regarded as being too specific.

However, when a field becomes part of general culture, its technical nature is accepted. We should remember that a large part of school education in a country like France is devoted more to literature and its techniques than to language as a tool for thought and communication.

From this point of view, discussions about technology contain features of a much more general debate that exists about all subjects—for example, about music, to make an apparently distant comparison. There is much at stake for society in the determination of the content and values attached to technology in all its aspects, particularly the aspects connected with the links between technology and changing economic and cultural structures, and with general culture.

The object

How are technical activities in schools to be devised? Two requirements must be taken into account. The first follows from the aims discussed above, the intention of which is to include the main features of technological development among the subjects taught. The second requirement involves the school and educational practice accepting responsibility for these subjects. Deciding on subject matter, preparing activities and selecting the means are all occasions when choices will be made that will determine the nature of technological education.

All this is far from being a foregone conclusion. There will be many different pressures and entreaties for technological education to be defined in the form of a list of concepts to be achieved, which is possible but 'suicidal'. Conversely, there will be pressures and entreaties to limit activities to making a few things, or just to a few technical operations.

In reality, technological education must provide both for practical familiarization with projects, processes and roles and for the intellectual work necessary for technological thinking.

AREAS OF PRACTICAL FAMILIARIZATION

New things of decisive importance often appear here first. For example, at the end of primary school, French curricula now contain wholly new areas, such as electronic assemblies—mechanisms and electro-mechanisms—and computers and computer systems.

This means that certain objects have to be put into the classroom, handled, built or made. It is a matter of exploring technical fields. From this point of view, the areas thus defined are not 'projections in school' of the science or technology taught at the university, but school activities corresponding to productive or consumer activities. Electronic assemblies must therefore relate to industrial electronic construction or that of the radio ham, i.e. the technical world, and not to electronics in the university.

INTELLECTUAL TECHNOLOGICAL WORK

In order to arrive at knowledge, these areas of familiarization have to be questioned from a number of points of view that together make up technology. It will then be possible for the artificial object, or the useful 'natural' object, to become a technical object and be examined as such. It becomes the basis of various interpretations.

According to an interpretation that can be called 'technical', the technical object appears: (a) as an arrangement of material elements, or of 'information' (a computer programme is a technical object from this point of view); (b) as a system of inter-relating technical functions (here the way to knowledge is through the conceptual distinctions between object and environment: physical, technical, or economic, and between functions and operators or organs); or as (c) the application, often also a 'hijacking', of empirically or scientifically controlled phenomena (the major idea here is that of the 'principle' which guides the design and provides the foundation for the subsequent developments of technical objects).

But these points of view, which are traditional in vocational training, and more recently in general education, cannot exhaust the demands of technological education. An 'anthropological' interpretation has to be added, in which the object is a product resulting from a productive social organization; an item of merchandise in a system of circulation and trade; a part of a social environment, an agent of social change, the physical medium through which symbolic values are expressed, the trace of a civilization.

Technology should therefore find a place among the human sciences if it has to be placed among the sciences.

This point of view corresponds to elementary and middle schools, but needs to be supplemented by taking account of the technical systems and networks for older pupils.

Approaches

How can activities that are consistent with these basic options be described now? There are two main types of approach that can give technological activities a direction, namely, exploration, which must include observation, experimentation and inquiry, and creation, with its phases of design, manufacture and use.

Exploration is obviously not specific to technology, but it is necessary if, among its aims, priority is given to understanding a technological environment. The exploration activities will thus be technological, less because of the choice of objects than because of the points of view attached to those objects, as they were described above. This approach is thus essentially analytical, guided by a form of questioning that carries within it the technological orientation.

Creation plays a fundamental role. It can in fact be subdivided into two approaches well known in teaching, namely, the overall, direct, empirical approach to all the aspects of an area of practical familiarization, and the integrated approach, favoured when one seeks to apply and include everything that has been learned or constructed in order to make a decision.

In technology, the integrated approach revolves around two essential notions—that of the technical project, which is the objective, detailed expression of the aims, conditions, limitations and means in accordance with which creation is going to have to be carried out, and that of a contract for creation, which is a mutual commitment to carry out the work in conformity with the technical project.

These two notions have to begin with a technical significance as they reproduce essential elements of contemporary socio-technical processes in industry and services.

They are far more than this, however, because it is here that technology meets teaching. It is the contract, based on the technical project, which will give direction to the activities of the class group by specifying each person's roles and responsibilities: teacher, groups, pupils. Lastly, these notions, explicitly expressed and applied, and related to a wide-ranging practical experience, will give their technological meaning to exploration activities in, and above all outside, school (Rak et al., 1992).

At this stage, it is worth bringing together a number of the proposals made around the guiding principle that gives them direction. Indeed, for all the components of technological activities in school, links have to be made with what is going on in real areas of social activity. This is true of objects, projects and roles. School activities are therefore planned as images of social practices. This is one final fundamental notion—that of the practice of reference (Martinand, 1986).

What does this mean?

In the first place, it serves to draw attention to the fact that in technology (although this is also true of many other subjects), one cannot restrict oneself to knowledge alone, nor even to the teaching situation, to judge the relevance of content. All the components of a practice must be taken into account, such as problems, objects, tools, knowledge, attitudes and social roles.

In the second place, it serves to draw attention to the relationship between the practice taken as a reference and the school activity. The relationship cannot be one of identity, nor even of 'reduction', but must be one of 'transposition'. There are necessary differences between the reference practice and the school activities, which must be determined and checked, precisely and in detail, if one of the aims of the activities is indeed the ability to interpret reference practices.

In the third place, it is important to understand that the differences are as much the result of the limitations of the school in terms of costs and time as of the pupils' and teachers' abilities and the conditions of the teaching-learning process, with its progressive phases of varied activity, separated by breaks.

In the fourth place, the idea of reference implies the possibility of there being many references and hence the need for choice. It seems that the consistency and meaning of an activity depend very much on the practice of reference and that the choices, at any given moment, are broadly exclusive. It is here that one sees the links between the science of teaching, in the shape of knowledge and implementation of the conditions for consistency, and policy, in the shape of the choice of the most suitable reference practices.

The thresholds

The transposition, for teaching purposes, between the chosen reference practice and the school activity is therefore a fundamental task. The question of technological education in school should certainly be put in the following terms: are there minimum requirements, or thresholds, if this transposition is not to become a distortion? It would be irresponsible to seek to add technology as a ready-made subject like the others. It still has to be built up throughout the world and a forced introduction would very likely be rejected.

The only reasonable prospect is to gradually introduce and develop activities which all take their direction from the points of view that form the basis of technology. Three development criteria can be distinguished for this, namely: introducing new technology such as computers; studying the technical, social and historical aspects of work; and constructing technological concepts.

We must pause a moment at these concepts needed for technological thought. The corresponding ideas are accessible from the end of kindergarten and certainly at primary school, provided that they are not confused with the imposed use of pedantic terms. The following notions must be examined: technical functions and operators, and working material (the distinctions here form the very basis of technical concepts); materials and shapes; properties associated with materials and properties associated with shapes; the industries of shapes or properties; the operation and the programme; the technical principle and technical development; the technical division of labour; economic relationships.

The learning of these analytical and conceptual tools must be continued throughout compulsory education. It is now a matter of urgency to lay down very precisely all the levels at which they are to be developed, with regard to areas of familiarization, possible school activities and children's abilities. It will not be possible to speak honestly of technological education unless there is at least some conceptual framework.

At the same time, the range of socio-technical reference practices must be broadened. Traditionally, this still had some meaning in the nineteenth century. Craft and domestic practices were given priority in primary schools, and industrial practices beyond that. Contemporary industrial and service practices must be taken into account. To do this, it is not enough to introduce new objects. There are ways of using computers in schools which close the school in upon itself and lead to it becoming its own reference point. This is not technological education. World society inhabits an urban environment full of technology. This is the new environment to which technological education must surely give operational, conscious access.

Lastly there is the problem of taking the technical and social dimensions of the work into consideration. More generally, technological education which is unable to provide reference points so that one can find one's way among the connections between the development of knowledge and scientific approaches, and among changes in technology and its impact on society, would not be fulfilling its role.

Conclusion

In everything that has been said in this article, the aim of which is to depict what technological education may be like in the twenty-first century, stereotypes about university and school subjects have been set aside in favour of breaking down and reconstruction, the essential phases of which are: establishing concepts for technological thinking; areas of practical familiarization and their reference practices; and exploration/creative activities, with the notions of contract and project. This is necessary to ensure that technological activities have at least a modicum of authenticity and consistency (Séminaire de didactique des disciplines technologiques, 1990/91, 1991/92, 1992/93).

It is also necessary if a number of generally accepted ideas, which are like pitfalls, are to be avoided:

The pitfall of objects. It is commonly thought that manufactured objects by their nature come under technology and that natural phenomena come under the so-called 'natural' sciences. Nothing could be further from the truth. Firstly, physics and biology have from the beginning been both natural and artificial sciences. Furthermore, there are technical uses of natural phenomena, and therefore technological knowledge concerning them. Lastly, true technical objects are never completely artificial. The laying hen is probably one of the best examples of a technical object accessible to children.

The pitfall of the simple and the complex. It is not possible to give priority to one or the other in technological education. In some countries, nursery-school children are familiar with computers. Approaches have to be found which make it possible to directly develop partial but authentic technical knowledge about them. Obviously, children do not have to follow the same road as their parents. Conversely, it would be risky to abandon simple objects, the understanding of which can be more complete and which can serve as pegs on which thought can be hung.

The pitfall of uniformity. It is sometimes said that there is one 'technological approach' and that it must be repetitively followed in order to be absorbed. Technical activity and technological thought are more varied because they have above all to solve problems and not conform to a systematic approach.

Teaching constraints themselves introduce other reasons for adding variety.

There is no such thing as a typical object, special situation or single approach. Once again, the only criteria are authenticity and consistency.

Within the framework of general education, technological education cannot be defined in isolation from the rest of culture. But it is on the basis of the whole-hearted recognition of the special characteristics of technology that technological education can be better situated in relation to educational activities as a whole, and their unity can thus be brought out. The fact that technological education seems to be a necessary component is its best chance for being accepted and developed.

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SCIENTIFIC AND TECHNOLOGICAL TRAINING FOR TRADITIONAL COMMUNITIES

Raúl Gagliardi

The International Bureau of Education is launching a research project on the training of teachers for intercultural education. The project is called 'Basic Education for Participation and Democracy: Key Issues in Human Resources Development (Teachers and Multicultural/Intercultural Education)'. The general objective of the project is to develop countries' capacities to improve basic education, especially in multicultural contexts, and particularly through teacher training. Another objective of the project is to improve teachers' capacities to educate minorities, which is an important element in the building of a more democratic society.

This article summarizes the results of the project and integrates them with strategies and methods developed by the Laboratoire de didactique et épistémologie des sciences of the University of Geneva, the Department of Biology of the University of Pavia and other research and training centres in Europe and Latin America.

Introduction

Many traditional communities are experiencing a rapid process of transformation. They are changing their way of life, their members are migrating to urban areas and undertaking new activities. When members of traditional communities leave behind their society and adopt a modern style of life, valuable knowledge is lost, and they often adapt poorly to the new living conditions. Alcohol and drugs are

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frequently the answer to the discrimination and low self-esteem they suffer. A common result is that pupils from traditional communities are less successful than pupils from other communities.

Many traditional communities want to maintain their way of life. However, their contact with Western civilization is growing and the pressure for change is increasing.

The teaching of science and technology could improve the situation of members of traditional communities by enhancing their use of resources while reinforcing their self-esteem and improving their performance in schools. Science and technology teaching could allow the maintenance of traditional knowledge and integrate it with modern knowledge.

The gap between traditional beliefs and scientific knowledge is not easy to bridge. This is not a philosophical question, but rather a very practical one; learning basic scientific concepts is very difficult if the learning obstacles presented by language and culture also have to be overcome.

Experience shows that results are better when science and technology teaching is consistent with traditional teaching methods, adapted to the characteristics of the community and low in expenditure of time and money. One Maori educator and political leader summarized the problem of science teaching for traditional communities by saying: 'give us the science, but maintain our pedagogy' (Ohia, 1990). In other words: maintain the traditional ways of transmitting information to new generations while providing useful scientific and technical knowledge.

The adaptation of teaching to the learners' culture is a very important element in science and technology instruction in any society, in any school. In traditional communities, adapting the teaching of basic scientific concepts to the community, its traditional knowledge and its beliefs is a fundamental element for success.

Knowledge about the characteristics of the community is therefore as important for the teacher as scientific and technical knowledge. The teacher should be capable of constantly evaluating his/her activities and adapting them to the community's degree of understanding and motivation about any proposed technological changes. He/she should anticipate resistance to technological changes in the community and interact smoothly when necessary. These ideas are consistent with a basic hypothesis developed in the teaching of science: a successful approach to improving science teaching results from an analysis of learners' concepts, attitudes and needs, and applying this information in teaching.

This methodology developed in the teaching of science could be integrated with the results obtained from research on multicultural education to provide a framework for improving science and technology teaching in traditional communities.

Improving the quality of life

The failure of development programmes in many developing countries and the problems caused by poverty, underdevelopment and environmental degradation are strong justifications for organizing educational programmes specifically addressed to traditional communities. Another element to be borne in mind is the discrimination suffered by traditional communities and the illiteracy—and scientific illiteracy—of most of their members.

Members of traditional communities can use basic scientific knowledge to improve the quality of their lives. For example, basic knowledge about micro-organisms is useful for improving public health. A health education campaign organized around such knowledge can reduce the high mortality and morbidity rates found in developing countries. Improving the quality of handicrafts can augment their market value. Improvements in conservation techniques can lead to a rise in the quality of food products and prevent them from deteriorating, thus reducing illness and mortality caused by diseases arising from poor conservation. Since many women walk five or ten kilometers to obtain wood for cooking, knowledge about solar cookers can lead to significant savings of time. The use of solar cookers can also reduce the incidence of eye diseases provoked by smoke produced from burning cow dung or wood for cooking—a significant problem suffered by women in developing countries.

Major environmental problems caused by human activities can also be reduced by introducing basic scientific knowledge into traditional communities. For example, basic knowledge about energy can be used to reduce deforestation resulting from the burning of wood as fuel for cooking. Knowledge about the dynamics of fish populations can be useful in reducing the negative impact of overfishing which may bring about the disappearance of certain species.

An analysis of costs/benefits and a measure of the impact of innovations at the ecological, economic, cultural and social levels may reduce problems associated with introducing innovations necessary for improving the quality of life. Therefore, science and technology instruction should not be limited to a simple transmission of information; it should develop the capacity to understand the reasons for these techniques and to analyze the costs and the impact of their implementation.

The transmission of basic scientific knowledge for sustainable development can be undertaken through different channels. Basic education is one of them, if appropriate educational activities are carried out and teachers develop the new capacities necessary as agents for sustainable development. This approach requires teachers who can interact with the learners' culture while teaching.

Pupils may transmit to their families the basic scientific concepts they have learned in school, if these concepts are appropriate for solving day-to-day problems. If this approach is used, pupils may become agents for sustainable development in their families and in their communities.

Pupils from traditional communities frequently have to participate in work with their families. This situation leads to difficulties in their studies and reduces the duration of their schooling. For example, children from nomadic communities leave school during migrations, and pupils from agricultural communities leave school during the harvest season.

Science and technology instruction should consider these activities. Learners' experiences in productive activities can be exploited in science instruction. Analysis of traditional activities can support science and technology instruction while the basic scientific concepts learned in the school can, in turn, contribute to improving traditional productive activities.

In a traditional community where fishing is an important activity, an analysis of fish conservation methods can be the basis for teaching about micro-organisms. Starting from such an analysis, it is possible to focus the lesson on the action of micro-organisms that cause fish to decay, showing that freezing, salting, drying or smoking are methods for preventing the multiplication of micro-organisms, and that hygiene is a way to reduce the quantity of micro-organisms and insects present. This analysis of methods to prevent action by insects can be used to overcome beliefs about the spontaneous generation of life and can be integrated into teaching about ecosystems and insect life-patterns.

In communities where agriculture is the main activity, analysis of farming methods can be the basis for teaching about such subjects as the transfer of matter and energy in environmental systems, or photosynthesis and plant nutrition. In return, an understanding of related scientific concepts can be the basis for improved farming methods.

Discussion about traditional methods should not be reduced to a few lessons about traditional culture. Analyses of traditional activities should be integrated into the mainstream educational activities, particularly in courses about science and technology. These analyses require information about traditional methods, and scientific knowledge about the processes involved. Therefore, research about traditional knowledge and its integration into science and technology teaching should be organized to obtain this information.

Building scientific concepts

An important element in training traditional communities is that the information should not be merely a ready-made solution, but rather an organized series of basic scientific concepts.

One temptation is to reduce training to a series of skills that can be mastered without any scientific explanation. Some advantages of this method are the rapidity of the instruction and the apparent elimination of cognitive problems. The basic idea is that it is easier to learn a series of tasks than to build new scientific knowledge that may contradict traditional beliefs. This skill-centred model seems to be readily adaptable for teaching in traditional communities. Therefore, the training of instructors in multicultural contexts is frequently oriented more to communication methods (how to teach the skills) than to the scientific content. However, experience shows that this approach has serious limitations. For example, it does not develop the community's capacity to grasp the reasons for the proposed techniques and adapting them to changing conditions. Another disadvantage is that it does not provoke the necessary conceptual changes in community members; some of them may acquire the proposed skills, but the community does not build a new conceptual framework as a support for understanding and solving the main problems. The most important objection to this approach is that it does not develop the community's capacity to understand the real problems, their causes, the possible solutions, which solution is best, and what are the possible repercussions of the chosen solution.

I propose a different approach: to focus teaching on basic scientific knowledge that can develop an understanding of the causes of problems and ways of solving them. New skills should be understood as a logical response to the causes of the problems, and not as a simple list of tasks to be performed without explanation. The accent might be put on understanding the causes of the community's problems, and giving a scientific explanation of the community's empirical knowledge. The necessary modifications for the community's activities will be deduced after learning the basic scientific concepts explaining the cause of the problem and a possible solution.

Let me give an example. Infant mortality is a major problem in developing countries; in particular, the tetanus bacillus is a leading cause of death among newborn babies. Contamination of the instrument used by midwives to cut the umbilical cord is one common way of transmitting this micro-organism.

A course to train traditional midwives was organized in Peru. One of its goals was to teach ways of sterilizing the instrument used to cut the umbilical cord. However, a few months after the course, no change in infantile mortality was observed; more particularly, there were no changes in the rate of tetanus infection in newborn babies. Observation of the activities of traditional midwives who had been trained in the course showed that the steps for sterilizing the knife were perfect, but after sterilization and before cutting the cord, the knife was often placed on the floor. The midwives had learned the techniques of sterilization, but they did not understand the concept of contamination. They had learned how to sterilize, but they did not learn why it is necessary to sterilize. To avoid contamination, it is not only necessary to know the rules of sterilization, but also to know about the existence of micro-organisms and their multiplication. Without this knowledge, sterilization becomes only a series of gestures.

This example shows the importance of teaching basic knowledge about micro-organisms. These concepts are also important for other health problems. In some countries, 80 per cent of illness results from water-borne diseases. In developing countries, 25 per cent of mortality is caused by poor food conservation. An important obstacle in the understanding of the existence of micro-organisms is that they cannot be seen with the naked eye (even if their effects are perceptible). The notion of their presence everywhere runs against the physical evidence.

Observation of different phenomena provoked by micro-organisms is not sufficient for understanding their existence, but it is always possible to give another explanation, especially a magical one. For example, a child's death by tetanus can be interpreted as the result of occult forces, or in a fatalistic way. Phenomena, like the contamination of food by micro-organisms, are frequently explained as 'spontaneous transformation of matter' or 'reaction of the food with the air'.

The concept of micro-organisms provides an explanation for infectious diseases, environmental processes such as the transformation of organic matter into inorganic matter, and some technologies such as the production of alcohol or food conservation. This concept is the basis for scientific knowledge as well as very practical activities.

Using traditional knowledge

Curricula for basic education are frequently monocultural. They dwell on the history and beliefs of the dominant group. This situation may reinforce feelings of discrimination among pupils from minorities, and may cause pupils to lose their cultural identity and self-esteem. It is also a cause of poor scholastic achievement among pupils from the minorities discriminated against. This is a major disadvantage both in obtaining good jobs and for integration into society. Appropriate curricula for multicultural/intercultural education should integrate some of the history and characteristics of all communities.

Traditional communities have very accurate knowledge about their territory and have developed specific technologies for dealing with basic needs and the exploitation of their territory's resources. Traditional knowledge and technologies are not scientific; they were not developed using scientific methods and they are not supported by scientific theories.

Traditional knowledge and technologies are transmitted to new generations by tales, stories, proverbs, etc., which frequently include magic as an explanatory factor. Analysis of these elements could allow their use in science and technology instruction.

Traditional communities frequently have low self-esteem. This attitude results from centuries of domination and is related to their standard of living. The low standard of living (compared with the dominant social group) reduces self-esteem. Low self-esteem is an element which impedes activities which may lead to an improvement in the standard of living. Thus the learners' self-esteem is an important element for success or failure during teaching. The learner who has low self-esteem is not motivated to learn and has more difficulty convincing himself/herself that he/she is capable of learning.

The global question is: How can a traditional community be trained to improve its quality of life while at the same time maintaining its identity and improving its self-esteem?

Let me relate a story from Togo. A French counterpart (who told me the story) was responsible for training future teachers. She prepared practical lessons in biology, in particular on fermentation. Being sensitive to learners' difficulties and wanting to use traditional culture in teaching, she considered how she might employ traditional knowledge in science teaching. As in many African communities, it was the women of the region who prepared beer using traditional methods. She asked the students to gather information about the traditional techniques for preparing beer.

The students asked their mothers and brought the information back to the course. During the following discussions, they were at first reluctant to talk about the way their mothers produced beer; they were ashamed of the magic rituals involved. However, after a brief discussion, they accepted to present the information obtained. The analysis produced a very important result: in the different communities the magic rituals were different, but the practical activities were the same and, what is more important, they bore similarities to the modern beer production methods. The conclusion was obvious: each tribe, each mother had practical knowledge about fermentation transmitted through magical beliefs.

The question was: How to use these beliefs and empirical knowledge in science teaching? For example, the mothers said: 'it is necessary to use an old container to produce beer, because the god of the beer (or the spirit of the beer) lives in it'. The spirit of the beer living in the old container is, in scientific jargon, the micro-organisms that will lead to the fermentation of sugars into alcohol.

Empirical knowledge showed the necessity of using an old container to produce beer and the consequent explanation of the phenomena was related with the sacred or spiritual world. The absence of scientific explanations encouraged the concept of 'the god of the beer' as a cause of an important phenomenon. It is probable that the community reinforced its beliefs in a sacred or spiritual world by also applying them to current observable phenomena. The building up of religious or magical beliefs was an important element in the building of social and cultural rules.

The students were ashamed to talk about the magical rituals carried out by their mothers because these traditional activities did not correspond to the Western scientific world they admired. A process of acculturation and loss of identity was in motion. However, the understanding of the relationship between, and utility of, traditional techniques and knowledge changed this situation. The students were proud of their tribes who had produced empirical knowledge that was scientifically correct. Not only can traditional knowledge be the starting point for teaching scientific concepts, but its use can improve community self-esteem.

The mystic beliefs of the community can obstruct teaching if the teacher is not aware of them. However, these beliefs are frequently linked with empirical knowledge and can be a vehicle for empirically correct information. This duality is a fundamental characteristic of the traditional community, which learns from experience and transmits the knowledge by integrating it into a system of mainly mystical beliefs. Therefore, the teacher should not fight against the mystic beliefs, but regard them as obstacles to be overcome and as elements that can be exploited in teaching.

Science and technology instruction for traditional communities can be organized around traditional tales and stories related with traditional knowledge. A good example is the 'Gayngaru Plant Walk', a booklet for a course about botany in Nhulunbuy Primary School (Northern Territories, Australia). The text, addressed to primary school-teachers, tells the traditional story of the 'Wititj' (olive python) and gives information for organizing a journey in the bush country near the school. The text gives information about the walk and about the thirty-four plants which can be observed during it, describing their traditional use and their scientific names. For example:

Corky bark (Dhuyuwur): the pale green, fleshy fruits can be eaten when ripe or crushed to treat inflammations, sores or sore eyes. The botanical name of the plant is *Opilia amentacea.*

Using scientific concepts

Developing the community's capacity to solve basic problems and motivating it to undertake long and difficult activities involves more than simply providing it with ready-made answers. It requires the teaching of basic scientific concepts.

Basic scientific knowledge builds a new understanding and empowers the community to improve its quality of life. This basic scientific knowledge should be pertinent for the situation and for the community. Its relevance for the environmental, social and economic situation is evident. The lack of resources and poverty in traditional communities suggests the necessity of focusing education on themes related to swiftly improving the quality of life and the solving of urgent problems. Basic scientific knowledge should be adapted to the main problems that the community must solve to improve its quality of life.

However, adapting to the main issues is just one factor in deciding what scientific concepts should be taught to a traditional community. Basic scientific knowledge should be accepted by the community, because if the community does not understand the need for it, it will not do what is necessary to transmit and exploit it. In practical terms, if the members of the community responsible for validating and transmitting knowledge do not think it is important in solving specific problems, they will not transmit the knowledge to other members. Leaders, grandmothers or teachers—all who participate in the diffusion of knowledge—should be aware of the importance of the basic concepts to be transmitted to the community.

The success or the failure of an educational campaign depends on this acceptance. Would a community organize new activities if it was not convinced of their importance? The proposed innovations should be adapted to real conditions in the community. They should be acceptable in economic, cultural, technical, social and religious terms. They should also be consistent with the characteristics of the production and marketing system and consumer habits.

A good example of the mobilization of a community for new activities based around a new concept is given by two indigenous Andean communities in Ecuador. They carried out arduous work on a grand scale—digging fifty kilometers of canalization at high altitudes—to obtain pure water. Activities such as piercing tunnels through the mountains were organized after the community leaders understood a basic concept that they expressed as: 'the bad water kills our children'. Community leaders convinced the other members of the community and motivated them to become involved in very hard and unpaid work, but only after they had understood the relationship between contaminated water—'bad water'—and child mortality. The concept of a relationship between water and child mortality was pertinent for the community, and the community members developed new activities after they had grasped the concept.

Using understandable language

The preceding example demonstrates another important point in transmitting basic scientific knowledge to traditional communities. A scientific concept is not understood if it is not expressed in the language and words of the community. For a scientist, 'bad water' is not scientific, yet for the educator it can be the basic expression inspiring the complete system of training in order to obtain drinkable water.

Learning about 'bad water' is a step in becoming aware of water-borne diseases and pathogenic micro-organisms, basic concepts for the community's health improvement. Important elements in transmitting basic scientific concepts to a traditional community are to put them into colloquial language, use local examples and, when possible, exploit traditional tales or stories. Learning a scientific concept should not be made more difficult by employing words that are unknown to the community. More important than the words are the concepts they carry; scientific concepts should be understood in colloquial language. The concept should be built by the learner before he/she knows the corresponding scientific word. Scientific and technology teaching should be focused on the learning of basic scientific concepts and not on memorizing scientific words.

If we accept that the learner builds his/her own knowledge, we can easily accept that he/she uses the language and concepts he/she already knows. Therefore, it is necessary to use an understandable language in the presentation of basic scientific concepts. However, to use comprehensible language does not mean to reduce the scientific value of the information. This is a key point in education: how to transmit correct scientific information using understandable language?

Translating science into traditional languages

It often happens that science and technology texts do not exist in traditional languages. Translating them into traditional languages can be an important step in developing the scientific and technological capacities of traditional communities. The difficulties in translation are considerable, particularly when the language does not have a basic scientific vocabulary.

The translation is often carried out by linguists or experts in the traditional language, but who are frequently members of other communities. However, the participation of the community in the translation is a very important step in improving the scientific capacity of its members. A very good example of community participation in the translation of scientific texts is the Maori community's translation into their language of the science syllabus in New Zealand.

The struggle by Maori communities to improve their economic and social situation and the consensus about the importance of reviving the Maori language for maintaining Maori culture has motivated the organization of pre-school institutions ('nests') for teaching Maori to Maori children. The nests were organized using the traditional teaching structure in which the elders take care of the younger students in classrooms containing pupils of all ages. Maori speakers (usually the elders) were charged with teaching Maori to younger generations. This is a good example of the participation of members of traditional communities in education and shows that a community can take in hand an important educational activity.

The second step was to organize primary schools in Maori. One big difficulty was the lack of texts in Maori, in particular for science and mathematics. The New Zealand government nominated two commissions to translate science syllabi and mathematics syllabi into Maori.

The science commission was headed by a Maori expert in science instruction who did not speak Maori. The other members were teachers, scientists, experts in the Maori language, etc. All of them were Maori and spoke Maori, and all tribes were represented. The translation of the science syllabus into Maori was carried out with the idea that all the words should be Maori words and not English words pronounced in a Maori way. However, the Maori language lacks many scientific words. In this case, new words were produced using Maori word-roots and Maori rules. Each new word was discussed by members of the different tribes and by teachers that used them in the school. When the commission adopted a word, it was discussed by the Maori Council which gave the final approval after considering linguistic, cultural and religious factors. Seven hundred words were created in this way and more than 1,500 members of the Maori communities participated. The translation of the science syllabus was completed in six months.

This example shows the possibility of a massive participation in translation and the possibility of transforming the traditional language by the introduction of new words that are consistent with the traditional language. The participation of the population in the discussion about how to translate each scientific concept is a mechanism for learning about science. A new word cannot be produced if its meaning is not understood. If the scientific concept behind an English word is not understood, it is not possible to translate it by creating a new word.

I had the opportunity to participate in a field trial to translate mathematical concepts into the Maori language. I am neither a Maori speaker nor a mathematician, yet I was pleasantly surprised at how well the understanding of mathematics developed in a discussion about how to create a new word using existing Maori words. This is a strategy that can be very useful for science teaching because it allows the formation of scientific concepts using unscientific words.

The problem of bilingualism

Frequently, pupils from traditional communities are bilingual. They speak both the traditional and the dominant language. Bilingualism is not a problem if pupils are fluent in one of the two languages; however, if they are not, they have significant learning problems, particularly in mathematics and science. This situation is frequent among migrant children and children who speak a non-standard dominant language such as Pidgin English or Aboriginal English. In both situations it is very important to help the pupil develop the correct language necessary for integrating scientific and mathematical concepts.

To talk or write about abstract concepts and relationships, and perhaps also to fully understand them, depends on using carefully structured language. There is plenty of evidence that many students in school and in teacher-training courses have not acquired the linguistic skills necessary for clarifying concepts and expressing mathematical ideas (MacGregor, 1991).

Overcoming learning obstacles

Scientific ideas are frequently counter-intuitive, and cannot be understood by simple observation of phenomena; they are often beyond everyday experience (Wolpert, 1993). Moreover, the development of scientific and technical literacy cannot be obtained through a simple transmission of information, and listening to or reading scientific texts is not sufficient for building basic scientific knowledge and developing a basic scientific capacity. These objectives require a long and difficult series of co-ordinated learning activities. The basic assumption regarding the didactic approach is that a learning process is not a simple acquisition of new information, but a complex process of transforming conceptual frameworks by reorganizing old concepts and elaborating new ones.

To learn something is to introduce a new element into an existing cognitive system, leading subsequently to a reorganization. The cognitive system gives significance to new information and integrates it into a new totality. If the cognitive system is not capable of incorporating new information, it is impossible to learn the associated concepts. Learners often have difficulty understanding scientific concepts because they do not have the necessary conceptual, logical and linguistic background. They have 'learning obstacles' (Gagliardi, 1991, 1994; Gagliardi & Alfthan, 1993) that can be affective (the knowledge conflicts with their beliefs), cognitive (they lack the necessary conceptual background), logical (they lack the necessary logical capacity) or religious. All these obstacles should be considered in the elaboration of educational programmes and in teacher training. It is also very important to consider the characteristics of the community, its culture, religious beliefs and methods for transmitting information and education. The success of an educational programme will be greater if it is adapted to all these conditions.

To identify learning obstacles it is possible to apply a method developed in social psychology and used in science teaching, called 'analysis of learner's representations' or 'analysis of learner's conceptions'. The objective of this method is to understand the knowledge and beliefs a person has about a particular subject. The method consists of analyzing the answers to a few questions and deducing the knowledge, beliefs, structure of causality and logic used in the answers.

If the teacher knows the learners' capacities and learning obstacles for a particular subject, he/she can organize the teaching to help them surmount the obstacles and build new knowledge. It is important also to know the ideas, beliefs and knowledge about this subject. These elements are part of the conceptual framework. Each of these elements is called a 'representation' or 'conception'. A conception is a specific concept about a specific subject. Identification of each conception is an important activity in the organization of teaching activities.

Conceptions are elements used for the interaction between the individual and the world around him/her, and which the individual uses to build new knowledge. Conceptions are built by each individual. However, this does not mean that there are a multitude of conceptions: each individual reproduces the fundamental conceptions of the society in which he/she lives. Research in science teaching shows that people in different countries have similar conceptions. However, it is necessary to analyze the conceptions in each country because the differences can be important. The analysis of the conceptions can be part of the teaching itself.

To know the learners' conceptions is of great help because they allow teaching to be organized as a function of the specific knowledge and beliefs of the learners. The information about learners' conceptions can be used for different purposes, such as to identify learning obstacles, evaluate the teaching and employ pertinent examples for teaching. Conceptions are good indices to measure learning. If, after a teaching activity, the learners have the same conceptions as before, the activity was a failure; in other words, learning implies a change in conceptions. The analysis of conceptions in relation to one subject enables the teacher to understand what the obstacles to learning are and the possible starting points for teaching.

The motivation of learners is important for the success of a teaching activity. One way of motivating the learners is to discuss problems that they recognize as important, and to give examples with which they are familiar and can understand. In this way the teaching is pertinent for the learner.

'Structurant' concepts

Overcoming learning obstacles is a fundamental aspect of teaching. When the teacher knows what obstacles to learning a particular pupil has, he/she can organize the teaching activities to overcome the obstacles and provoke the transformation of the cognitive system. The teacher should not give much information before he/she has ascertained that the obstacles have been eliminated and the trainees can build on the new knowledge.

Instruction should be oriented to teaching a few concepts that—when internalized—transform the cognitive system and lead to a new conceptual framework, permitting further learning. I call the fundamental elements 'structurant concepts' because they define a new structure of the cognitive system (Gagliardi, 1983, 1987). When a structurant concept is learned, changes take place in the capacity of learning: it is possible to incorporate new information and build new knowledge. Simultaneously, a new capacity to observe the world develops.

The history of science illustrates very well the effect of elaborating and diffusing a structurant concept in a scientific community; it shows that there are moments of great conceptual change leading to major changes in theory and research. The evolution of science is not an accumulation of data, but a series of important conceptual changes followed by changes in the way research is organized to look for solutions to new problems. In other words, a conceptual change implies a new way of thinking, new problems and new instruments to solve them. Conceptual changes are correlated with technological changes. The evolution of technology in the last two centuries illustrates how the introduction of new scientific knowledge provoked major changes in production systems.

At the individual level, the process is similar: people cannot perceive all the phenomena around them because they do not have the necessary structure to integrate the perceptions. When an individual learns a structurant concept, new phenomena can be perceived, new problems identified and new solutions sought.

The problem-solving approach

There is a paradox in learning: how can the learner build the structurant concepts if he/she has learning obstacles? There is a solution to this paradox: the cognitive activity of the learners can be oriented toward discussing problems that are pertinent for them but which they cannot solve without building a new concept. The new concept allows the problem to be solved and also provokes changes in the cognitive system; it is, in my jargon, a structurant concept. Therefore, the activity of a teacher should be to introduce problems in the mind of learners and not to introduce information. The information should be given only when learners need it, and when they ask for it to solve a problem.

Language and culture

Traditional language can be an obstacle for learning sciences and mathematics in many ways: lack of words, and differences in grammatical structure or the patterns and categories used to portray the world. Watson says:

> Language is the system of signs that we hang on nature: names that we give to natural objects and creatures, processes and relationships. People of all cultures tend to think of their own language as neutral, believing that it 'maps' the world the way it 'really' is. Yet,

scholars have suggested that languages may sometimes provide dramatically different pictures of nature, actually dividing the world differently, using dissimilar categories (Watson, 1989).

Another difficulty in teaching science and technology to traditional communities is the differences between traditional thinking and scientific thinking. Traditional communities use information at the macroscopic level: they use the information gleaned from their own perceptions, without using technical instruments to understand the microscopic or molecular level of organization supporting the visible phenomena. This information is organized in mythical structures which provide significance and organization. In some traditional cultures, such as that of Australian Aboriginals, the traditional way of thinking is a strong obstacle to science learning. Christie says:

> The units by which the Aboriginal knows his or her world are large and available to perception, for example people, trees, animals, and rocks. These are generalized into unities or cosmic entities like the kangaroo or the crow which transcend form, space, and time. The abstraction proceeds only one step from what the individual perceives, and continues to be tied to it. The connection between the perceived and the abstraction is not a logical one. For example, an Aboriginal man who says that a particular area of land is his mother is not speaking metaphorically. To him the land is his mother in a literal way most White Australians will never begin to understand. [...] all Western notions of quantity—of more and less, of numbers, mathematics, and positivistic thinking—are not only quite irrelevant to the Aboriginal World, but contrary to it. When Aborigines see the world, they focus on the qualities and relationships that are apparent, and quantities are irrelevant. A world-view in which land, spirit beings, people, and trees are all somehow unified does not lend itself to scientific analysis. [...] The Aboriginal world-view provides for the unity and coherence of people, nature, land and time (Christie, 1992).

Some of the difficulties an Aboriginal pupil has in understanding science are related to the lack of Western mathematic elements, such as numbers, in the Aboriginal language. Australian teachers are developing a new strategy for teaching mathematics, based on the capacities that Aboriginal pupils have developed (Kepert, 1993). For example, the ability to recognize the very complex and abstract systems of personal relationships in the Aboriginal community, or the knowledge about territory and the capacity to situate oneself in it. To teach fractions it was proposed to use as examples clan organization or the traditional way of cutting a fish into three parts. Using these strategies, Aboriginal pupils show the same or greater mathematical aptitude as that of pupils from Western communities.

Magical beliefs and taboos

Each community has developed knowledge, skills and practices useful for ensuring its livelihood and survival. Communities also develop beliefs related to their activities. Traditional knowledge and beliefs are transmitted from generation to generation, and can be both a positive and a negative element in science and technology training. They provide a basis upon which to build new knowledge, yet they can hinder new learning and the undertaking of new activities. Training programmes should therefore try to reinforce empirically correct knowledge and skills while helping people to abandon unscientific beliefs. People can be encouraged to abandon unscientific beliefs by making use of other beliefs. For example, religion was used in a successful educational campaign to promote rat control in Malaysia. Farmers believed that rats would take revenge upon their dead by causing worse damage. Citations from the Koran such as 'the more rats you kill, the more you will be rewarded in Heaven' and 'as a Muslim, it is sinful to be superstitious' were used by religious leaders in Friday prayers, in leaflets and on radio spots (Food and Agriculture Organization, 1987).

In Kenya, excessive wood-cutting has resulted in deforestation and is forcing women to spend several hours a day collecting wood further and further away from their homes. A programme of afforestation has been implemented to reduce the need for women to undertake this arduous and time-consuming work (Obel, 1989). The programme has also generated new economic activities, such as growing fruit and extracting wood from the forest. Other benefits have been greater biodiversity and improved working and living conditions as the forests give shade and reduce temperatures. But the programme has met cultural resistance; in some regions, planting trees is considered an essentially male activity and taboos prevent women from engaging in it. Beliefs that the trees will die, that the woman will become sterile, or that her husband will die if she plants a tree are examples of such taboos. They favour the traditional view that men alone can own land, and that if women own trees they might then claim the right to the land. Some women have overcome these taboos, using young men to do the actual planting of trees while they undertake all the other forestry tasks.

Pupils that live in urban areas but maintain some traditions also have taboos that are obstacles to the learning of science. For Aboriginal girls it is very difficult to discuss subjects related to sexual education if the courses are given by men. Information about the body and sex is taboo. Teaching about this subject is usually done by elder women in the family, and therefore men should not be present in a course about sexual education addressed to Aboriginal girls.

Temporal organization

A major problem in introducing new techniques into a traditional community is the kind of temporal organization with which members of the community are familiar. Temporal organization is linked with the perception of time as well as perception of planning, organization and achievement of activities.

Edward Hall, who analysed communication problems between cultures, discusses two main cultural systems:

The first, the 'monochrome system', is characteristic of highly developed societies where the organization of time is rigid—one thing at a time—and specific value is given to time ('time is money'). The perception of time is precise. Activities are organized following a precise temporal measure (days, hours, minutes). In this system the accomplishment of activities takes priority over social demands. This system favours the planning and achievement of new techniques.

The 'polychrome system' is characteristic of societies with a high degree of conviviality, where social and family relationships are most important in the accomplishment of activities. In this system it is possible to perform several activities simultaneously, and time is not a value in itself. This temporal system is not favourable for the planning and application of new techniques if they involve a rigid temporal organization (Hall, 1974, 1987).

When teachers work in a community with a polychrome system, they should be aware of its characteristics and of its advantages/disadvantages for the organization of teaching activities.

The main advantage of a polychrome system is the highly-developed network of social relationships that can ease the diffusion of information. Another positive characteristic is the conviviality that stimulates participation of community members in teaching activities. One negative characteristic is the fact that the polychrome temporal organization is contrary to the introduction of some of the new technologies.

The necessary changes in temporal organization and perception are an obstacle to the use of new techniques. Temporal organization is linked with psychological structures internalized in the first years of life and is essential in the establishment of relationships between the child and society. These structures do not change easily. Therefore it is not useful to talk about the need of 'working fast' or to discuss the need to avoid interruptions. For example, a main element in food conservation is reducing the action of micro-organisms by reducing the duration of some steps in the processes. Observation of some polychrome communities shows that food conservation activities are frequently delayed by social activities, such as talking between friends. The delay provokes an important loss of quality in food products, with a consequent reduction of value and an increase in health risks. Any course about food conservation should consider the polychrome approach and convince the community about the necessity to work as fast as possible at some stages.

The need for a new temporal organization may be discussed in a practical way, for example, by analysing the duration of each step of the proposed activities. Science and technology instruction can also discuss the necessity of planning productive activities and the consequences that a polychrome approach has on the quality of products. The participants are possibly not aware about the time spent in activities other than those related with production. The analysis of one's own activity can be a good way of showing the need to avoid lost time in processing activities.

Multicultural education and teacher training

Science teaching addressed to traditional communities is a particular case of multicultural education. As in any other case of multicultural education, the role of the teacher is fundamental. Science and technology teaching for traditional communities cannot be improved if general issues of multicultural education are not considered. A synthesis of the issues follows (Gagliardi, 1994):

Multicultural education is a way of reinforcing the cultural identity of pupils from all communities, including minorities. It stimulates the pupils' self-esteem by developing their knowledge about the characteristics and achievements of their own community. It also enables negative attitudes towards other communities to be overcome through awareness of their characteristics and achievements.

Utilizing cultural and language diversity is frequently considered a negative element in education. However, it can be a resource in classroom activities if teachers are capable of accepting pupils' conceptions and knowledge and can stimulate pupils to share them. Pupils' family life, cultural background and experiences can be important resources for teaching. This approach stimulates pupils' self-esteem and can help them surmount shyness and discriminatory feelings by developing mutual understanding and solidarity between pupils from different communities.

Differing educational objectives among communities. Monocultural education sets homogeneous educational objectives for the whole population. However, different communities can have different educational objectives. To accept these differences and to adapt schooling to them is an important issue for schools in multicultural contexts. This can be a difficult point when communities have very different objectives. In this case a 'bicultural school' seems a possible solution. Teacher training should include information about the educational objectives of the different communities and how to integrate them into curricula.

Teacher ethnocentrism. It is necessary to help teachers to surmount ethnocentrism and negative attitudes about minorities. These are an obstacle to understanding the pupils' cultures and accepting pupils' particularities. The analysis of teachers' conceptions and attitudes concerning pupils' communities is an important factor when organizing teacher training for multicultural/intercultural education.

Considering each pupil. Multicultural/intercultural education requires a particular capacity to adapt teaching to pupils' characteristics in a learner-centred approach. Some teachers' conceptions and attitudes concerning teaching and learning can obstruct the development of this capacity. For example, teachers frequently think that 'to teach' is identical to 'transmit information' and to learn is equivalent to 'listen and remember'. These teachers are not very concerned by pupils' characteristics and they do not adapt teaching to pupils' learning difficulties. Teacher training should help teachers modify these conceptions and develop consideration for pupils' characteristics and learning difficulties. Analysis of teachers' conceptions and attitudes about teaching and learning is an important element in teacher training.

Adapting to pupils' difficulties. Understanding the pupils' learning difficulties is a fundamental element in any educational activity, particularly when the teacher comes from a community different from that of the pupils. The analysis of pupils' conceptions and attitudes is an important component in a learner-centred approach. Teacher training for multicultural/intercultural education should include methods for analyzing pupils' conceptions, attitudes and learning obstacles, and should develop strategies and methods to help pupils overcome them.

Taboos and rules of communication. Frequently, teachers have problems communicating with pupils from different cultures. If teachers do not know the basic rules of communication used by pupils, they can have difficulties in establishing good relations with pupils. Another related problem is caused by pupils' taboos: if teachers do not take into account pupils' taboos, they can hurt the pupils' feelings and provoke a sense of rejection. Teachers in multicultural contexts should learn and use the communication rules of the pupils' communities and should be aware of pupils' taboos, adapting their activity to them.

Family participation in school activities is an important element in the pupils' achievement. Teacher training should develop the capacity to establish good communication with the families of pupils from different communities and to stimulate family members to participate more actively in school activities.

Multicultural training materials. Training materials are frequently monocultural, presenting only a dominant ethnic and cultural model. This kind of material may hurt the feelings of minority pupils and can reinforce discriminatory conceptions and attitudes. Multicultural education requires training materials which present all cultures and the history of all communities. Teachers should be trained in the production of multicultural training materials.

Conflict management. Teachers should be trained in education for conflict management. This training provides teachers with concepts and methods for developing the pupils' capacity to manage conflicts. Such methods also stimulate pupils' active participation in the peaceful solution of conflicts between communities.

Adapting to individual and community change. Frequently, traditional communities suffer major changes provoked by their relationships with Western civilization (migration, changes in languages, changes in life styles, etc.). The changes are not identical in all the members of the community and some members undergo more change than others. Pupils are not similar; it is not enough, therefore, to adapt teaching to community characteristics. Successful teaching requires adaptation to each pupil and avoiding stereotypes about the community.

The necessity of educational research

Science and technology teaching for traditional communities requires precise information about pupils' communities. This information should be updated continuously to keep abreast of the cultural, social and economic changes in the different communities. Research on obtaining and updating this information should be carried out at the local level. The information obtained should be incorporated into teacher training and transmitted to teachers. A well-organized system of research and transmission of information is an important element in multicultural/intercultural education.

Another necessary piece of information in multicultural contexts concerns the main learning obstacles of pupils. As already stated, this information is necessary in order to adapt teaching to pupils' difficulties. Comparative educational research should be organized to obtain this information.

The teacher as researcher

The problems mentioned above are difficult to solve. They require information about pupils and about their communities. However, communities and pupils change, and new information therefore becomes necessary. This situation can be resolved if teachers have the capacity to analyze their pupils in an ongoing manner, adapting their teaching to the transformations observed. In other words, teachers should be researchers in the classroom, analysing pupils' learning obstacles and using strategies and materials adapted to them. Teachers in multicultural contexts should not only be capable of establishing good communication with their pupils, but should also have an open mind and a scientific approach to teaching. Our experience shows that teachers can both develop these attitudes and capacities, and gain from analysing pupils' conceptions and attitudes.

Synthesis

— Science and technology teaching should permit traditional communities to develop a capacity for solving basic problems related to their quality of life.
— Science and technology teaching should permit members of traditional communities to overcome their low self-esteem.
— Traditional knowledge and technologies can be used in science and technology teaching. This strategy facilitates the teaching and permits the maintenance of useful knowledge and technology.
— Overcoming the gap between 'traditional' and 'scientific' thinking should not destroy traditional cultures and languages. This is a very difficult question: How does one develop scientific and technological capacities without destroying traditional culture?

— Teaching materials should be adapted to the culture, knowledge and communication characteristics of traditional communities and should not reinforce low self-esteem.

The teacher who teaches pupils from traditional communities should:

— Understand the communication rules and taboos of the community and be able to use this information in teaching;
— Be familiar with traditional knowledge, and the ways of transmitting it (tales, proverbs, etc.), and use this in science teaching.

Pupils from any community have learning obstacles. Pupils from traditional communities have obstacles similar to those of Western pupils, plus other specific obstacles. Some learning obstacles of pupils from traditional communities are:

— lack of mathematical and scientific elements in traditional language and culture;
— problems in language development, particularly for bilingual pupils;
— taboos;
— low self-esteem and feelings of not being capable of learning scientific knowledge;
— lack of family support for learning;
— low social and economic status;
— a traditional way of thinking in terms of magic, that is, a tendency to give magical explanations to observed phenomena;
— lack of knowledge about the microscopic level of organization and non-visible phenomena.

Improving science and technology teaching to traditional communities requires information about culture, traditional knowledge, the way of thinking and the specific learning difficulties. However, this general information should be complemented with information about the specific difficulties of each pupil to help him/her solve concrete cognitive problems. Teachers working in traditional communities should be able to organize research in the classroom to analyze pupils' conceptions and attitudes and learning obstacles. These teachers require additional information about each community's characteristics.

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CONCEPT MAPPING TO FACILITATE TEACHING AND LEARNING

Joseph D. Novak

What is a concept map?

Concept mapping originated in a research programme on children's understanding of important science concepts (Novak & Musonda, 1991). Although the technique arose as a tool of educational research, its use can significantly help teachers in planning instruction, as well as aiding authors in planning textbooks, and learners in organizing their learning.

Fundamentally, a concept map is a way to represent the structure of knowledge. Knowledge can be perceived as being composed of concepts and the relationships between them, called propositions or principles, arranged in a hierarchical structure. We define a concept as a perceived regularity in events or objects, or records of events or objects, designated by a label. Usually the label is a word, but it may also be a symbol such as + or Σ. While the symbols used to represent a given concept may vary from language to language, the regularity represented by the symbol is approximately equivalent. Since concept meanings derive from the context in which they were learned, culture and experience has an impact, so no two individuals conceive precisely the same meaning for any concept label. The differences can be larger between individuals in different cultures or speaking different languages; this is one of the problems in translation of text materials, since dictionary equivalents of words do not necessarily carry the same conceptual meanings.

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Concept meanings are acquired early in our lives when we learn that events or objects possess a certain regularity and this regularity is usually labelled as words by adults and older siblings. In this way we learn concepts such as hot, cold, cup, love and birthday party. Once a basic store of concepts is acquired, these in turn can be used to teach us other concepts. Somewhere between the ages of two and four, children move from the discovery of concept meanings on their own (concept formation) to the acquisition of concepts by using language (concept assimilation). Most school learning is essentially concept assimilation, where the meanings of new concepts, and relationships between concepts, are acquired through the use of language, and hopefully with the benefit of direct experience with objects and events.

Concept maps can facilitate the preparation of lessons, the sequencing of topics presented in a lesson, and the sequencing of lessons by teachers and authors. When instructional materials are planned from concept maps, it becomes relatively easy for students to grasp the meanings of the materials, especially if the students themselves are asked to prepare their own concept maps of the topic (Novak, 1991/1993). It is essential for students to learn to prepare their own maps in order for them to profit from the use of this tool.

Concept maps also serve as a useful vehicle for discussion between students and between students and instructors. Since the concept maps prepared by any two individuals will show at least some differences in structure, they create the opportunity for negotiated meanings between students and between students and instructors. This is an essential element in the facilitation of learning. It also permits students to see errors in initial concepts and concept relationships, and offers them more powerful ways to look into a domain of knowledge.

Finally, concept maps can be used for evaluation to assess what students know, both initially as they begin study of a topic and subsequently as they progress through the study. The maps can represent their understanding of relationships between different conceptual domains. Figure 1 shows a concept map describing the nature of concept maps.

Preparing concept maps

Maps can be prepared from almost any knowledge source. The easiest way to begin may be to select a section from a textbook or syllabus that is rich in conceptual content. The first map prepared by students might involve only a single paragraph, though it is generally better not to select a paragraph dealing with structure of an object or a taxonomic discussion. Students begin by circling key words or concepts in the text material and creating a list of these key concepts. Since almost every word is a concept label, it is important for students to learn to distinguish between the ordinary language concept labels and those labels that deal explicitly with the knowledge being transmitted.

Once concept labels have been identified, these can be ranked in order from the most general and most inclusive concept in the text selection to the most speci-

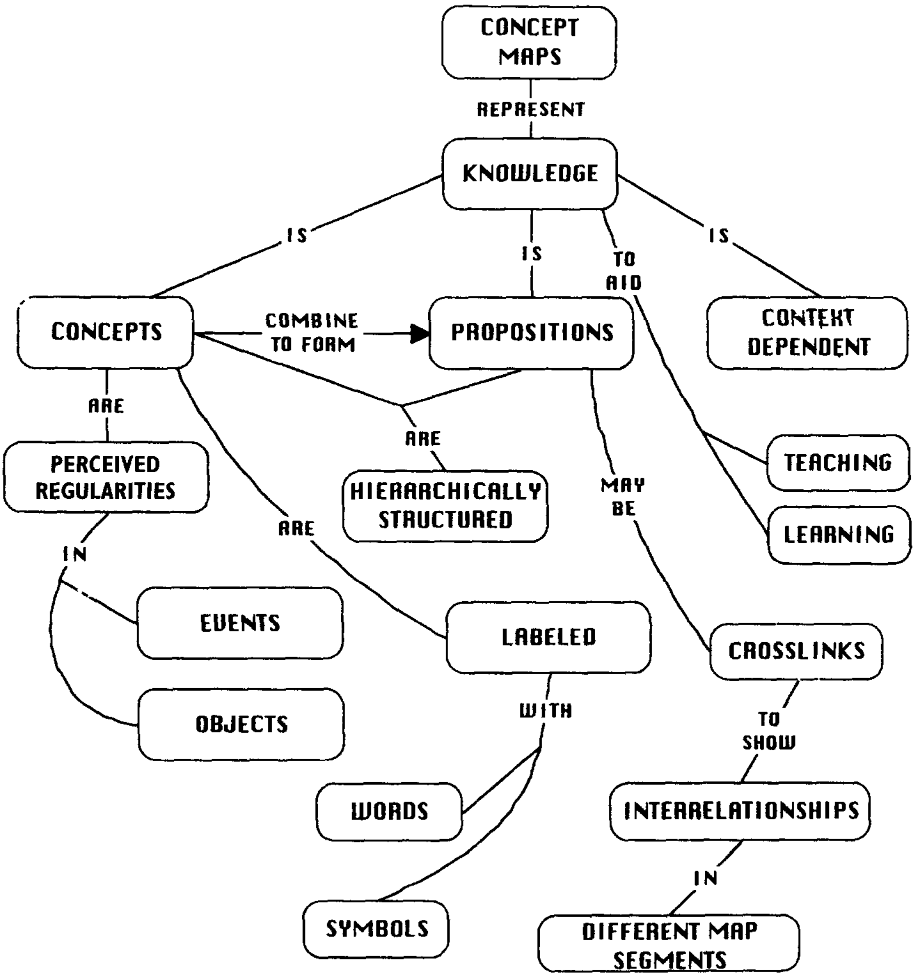

FIGURE 1: A concept map showing key features of concept maps.

fic and least inclusive. If the instructor chooses to build the first map with the students on an overhead projector, chalkboard or computer projection, discussion can help to reach some general consensus on the best ordering of the concepts. Of course, there is no perfect order or perfect structure for a concept map.

Next the concepts are arranged in a hierarchical (pyramid-shaped) structure with the more general concepts at the top of the map and the most specific concepts at successively lower levels. Refer again to Figure 1 as an illustration. The next step is to create statements or propositions that convey the specific meaning of ideas presented in the paragraph. Lines are drawn between pairs of concepts, and labels are selected to indicate the relationship between these concepts. The initial line labelling may suggest a restructuring of the concept map. Since this is always desirable, it is helpful to use pieces of adhesive note paper, which allow easy repositioning of concepts to form new hierarchies. Ideally, students would be given the opportunity to create maps on a computer screen, and much software now exists that permits this.

Once a reasonable hierarchy of concepts is established, and linking words and lines are constructed between all pairs, it is important to look for interrelationships between concepts on different segments of the map. *Cross-links* should be marked on the map and the lines labelled indicating the relationship. Cross-links are not always easy for students to find initially, but they are important because they help students to integrate the meaning of the ideas in the entire text. Of course, it is possible to link every concept with every other concept in some way, but only the most salient cross-links should be recorded on the map.

Finally, the map should be re-thought and redrawn, preferably after a few days of further study and incubation.

Application of concept maps

As indicated earlier, concept maps are basically a tool for representing knowledge. They are highly condensed and possess a hierarchical structure similar to the structure in which knowledge is stored in our brain. Therefore, concept maps can be effectively used to facilitate the writing of a paper or an entire book. They help the writer to organize key concepts and relationships, and also suggest a sequence for the writing beginning with the most inclusive and more general concepts. Since the more general concepts are usually ones that other people may understand, the organization of the map is also an effective organization for communicating ideas to other people.

To ascertain what students know, we can use concept maps drawn by the students, perhaps with a list of ten to twenty concepts presented with instructions to add more related concepts and appropriate linking words. They can also be used to plan interviews, or for research or for teaching insights, and then serve as a kind of template to evaluate students' understanding. Figure 2 shows a concept map used to plan and evaluate interviews with ten to twelve year-old students on the subject of photosynthesis.

It should be obvious from the above that concept maps can be effective for teachers in planning lessons or indeed an entire course syllabus. Once again, it is generally best to begin with the more general concepts and concept relationships and then proceed sequentially to the more specific concepts. One of the difficult challenges novice teachers face is how to move from topic to topic, and here concept maps can be helpful to both novice and experienced teachers. Of course, a very specific concept may be unusual and therefore a good way to capture students' attention, so the art of teaching requires good judgement in sequencing instruction, while in general following the principle of moving from more inclusive concepts to more specific ones.

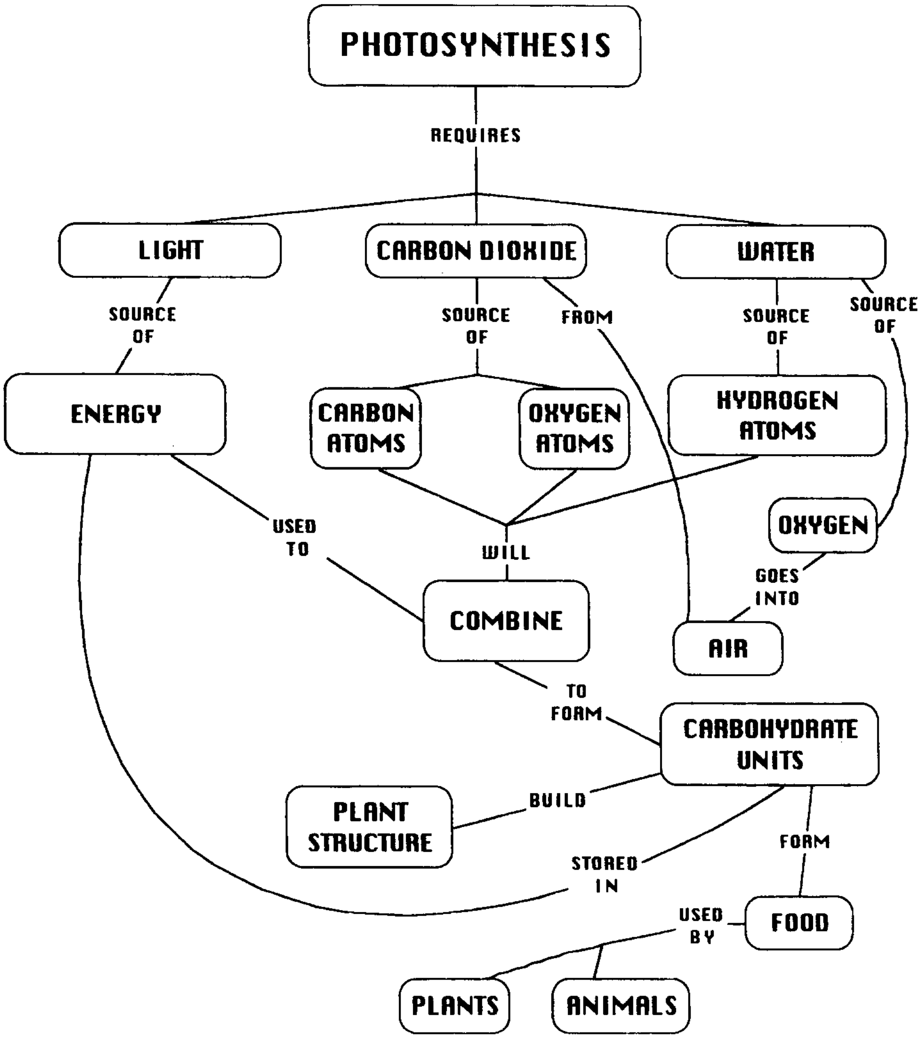

FIGURE 2: A concept map on photosynthesis used to plan and interpret interviews with 10- to 12-year-old children.

Concept maps can be effective in helping students organize knowledge so they can understand events in a laboratory or a field setting. The instructor might review some of the important concepts relevant to a given laboratory or field study, and create a list of these; the list can be used by the students in mapping their own knowledge prior to initiating the laboratory study. The maps might be more limited at this point, giving only the most salient concepts and relationships necessary to understand the observed events or objects. Following the laboratory or field activity, students could be asked to elaborate and modify their concept maps;

this activity can serve both as a capstone to consolidate the knowledge gained in the observations and as an evaluation method.

Concept maps can also be used effectively in facilitating collaborative work between learners. When two or more students work together to create a concept map for a given domain of knowledge, there will be much lively discussion and exchange of ideas, often using language familiar and meaningful to the learners, language that even experienced teachers often have difficulty constructing. Concept mapping can facilitate co-operative learning or collaboration of students in small groups. It is also useful to have students prepare concept maps individually and then share these in a small-group setting. One approach I have used successfully is to follow the sharing of individual concept maps with construction of a group map. Subsequently, group maps can be posted on walls or cabinets around the room and students might be asked to rank the group maps from most to least communicative. This provides both motivation for constructing good group maps as well as an effective learning experience. It also serves as an evaluation of students' thinking.

Students might also construct concept maps of other domains of knowledge, such as how to learn meaningfully (see Figure 3), or attitudes and values that are important in the learning of any subject matter. Concept maps can represent feelings and values as well as knowledge, if concepts are selected that express these ideas. The choice of linking words can also add feelings or values to knowledge structures by using such links as 'very important,' 'trivial,' 'most significant,' etc. In one of our recent studies, we found that concept maps dealing with working relationships, when shared between individuals and working groups, have been effective in resolving personal conflicts or obstacles, thus smoothing out work accomplishment (Fraser, 1993).

Evaluating concept maps

There is no one scoring formula that is most appropriate for concept maps, since concept maps may be used for a wide variety of purposes. In general, however, several features of concept maps can be evaluated and 'scored.'

Firstly, one can count the number of correct or relevant concepts included in a given map for a domain of knowledge. One or more points could be assigned for each correct concept. Secondly, each of the relationships indicated on the map could be checked for accuracy and one or more points assigned for each. It may be useful to offer more points for those relationships that use linking words giving high precision or specificity to the relationship rather than a more generic connection. For example, there is greater information and precision in the statement, 'photosynthesis--occurs in all--green plants,' than in the relationship 'photosynthesis--occurs in--green plants'. Of course, assigning variable points for the quality of propositions constructed on the maps is a judgement the teacher must form, much the same as evaluating essay exams or short-answer question responses.

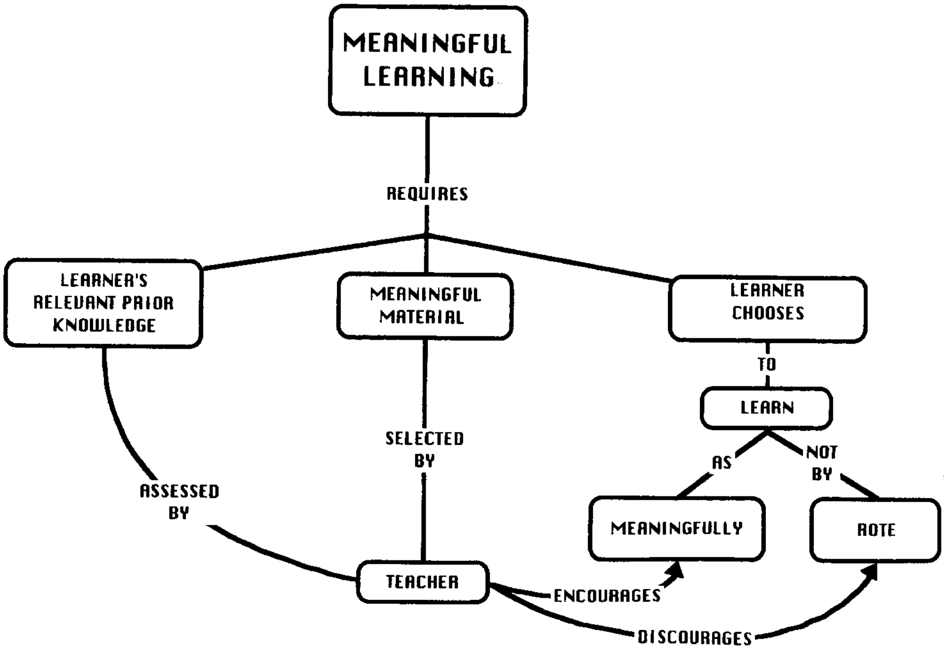

FIGURE 3: A concept map showing some of the key ideas to be considered by teachers and learners.

The teacher's judgement is also required to assess the quality of the hierarchy established in the map. This is very important, and I usually suggest that the quality of hierarchy receive at least as much credit as the relative number of concepts included in the map. Finally, it is important to look for significant cross-links or interrelationships on the map. These are very important and should receive more credit than simple relationships between two adjacent concepts.

One can deduct points for inappropriate or inappropriately-linked concepts. The degree of complexity in the scoring algorithm one chooses depends, in part, on the purpose of the work and the time and other concerns of the teacher.

The time required for grading concept maps is usually much less than for grading essay exams. Moreover, it is possible to cover a much larger domain of knowledge in the same amount of test time and with far greater precision.

Concept maps, when constructed by students, require that they not only have specific knowledge but that they be able to synthesize and evaluate this knowledge. Therefore, the maps represent the highest levels of evaluation and comprise what is now commonly called an 'authentic evaluation' tool (Novak & Ridley, 1988). After students are taught to use concept maps for learning, they are generally happy to be evaluated using concept maps, and they often express how efficiently the map represents their knowledge.

Facilitation of meaningful learning

Probably the most important objective in using concept maps is to encourage students to move away from rote memorization of information. The facilitation of meaningful learning, that is, the incorporation of new knowledge into the existing knowledge structure of the learner, is not easily done by students in most school settings. Preparation of concept maps requires that students seek out and understand relationships between concepts and domains of concepts, and this is an important way to facilitate and encourage meaningful learning. Students come to value concept maps as a learning tool, especially if these are also used in evaluation and constitute a substantial part of their course grade (Novak & Gowin, 1984).

It is easy to underestimate the difficulty that all learners have in reaching high levels of meaningful learning. Indeed, even experienced teachers find that when they begin to map domains of knowledge conceptually, their own less-than-optimal learning of the subject matter reveals ambiguity in their understanding of specific elements in the domain of knowledge. Concept mapping may not be the easiest tool to use for rote learning, but it is certainly one of the easiest tools to use to facilitate high levels of meaningful learning. In the end, this is their primary value and should be the primary goal of instruction.

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THE NON-FORMAL COMMUNICATION OF SCIENTIFIC KNOWLEDGE

Bernard Schiele

In an article on this subject, Barbichon (1973) rightly comments that the way in which scientific and technological knowledge is propagated in society is not homogeneous. It is not assimilated directly. In the first place, schooling, work, daily life, the groups one belongs to, ideological subcultures and so on are so many environments with differing effects on the circulation of knowledge. Secondly, many different activities undertaken by various transmitters of knowledge all help in its transfer. Thirdly, what helps the receiver to understand and absorb is the plurality of intellectual operations rather than a single act of learning.[1]

While there is no royal road for the distribution and transmission of knowledge, two main types of vehicles are recognizable: formal and non-formal education.[2]

The differences between formal and non-formal education

Presenting this contrast between formal and non-formal education (about which we shall have more to say later) could suggest that the one is structured because it relates to specific places (schools at various levels, institutes and universities) while the other is not and that the one has physical substance while the other has none. Nothing could be more misleading. Non-formal education is based on a network of institutions: associations, groups, clubs, museums, the book market, the radio and television markets and one-off and continuous government assistance. The

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dissemination of scientific and technological knowledge obeys a number of rules; it starts from distinct and well-characterized places, beginning first with those which inject these productions into commercial circulation and secondly with those which give it non-commercial distribution (token payment). Clearly these two spheres are not watertight. In any case, the cultural industries, of which the commercial conveyance of scientific and technological education is only one facet (Schiele, 1983), can only thrive if the two overlap (Huet et al., 1978, Miège, 1989). Hence an increasing autonomization in the communication professions (scientific communicators, museologists, media specialists, etc.) that is transforming the organization of the professions themselves and that of the disseminating structures as well. The growth of the cultural industries is tending to structure how scientific and technological knowledge is disseminated, the form of the product itself, as well as its production. This development has its effect on groups and clubs, whose activities traditionally escape commercial circulation.

Taking this analysis of the differences between formal and non-formal education further, school 'is a continuous process based on the assimilation of information in connected steps in order to construct a coherent set of knowledge. So each item of information is a part of a whole and the educational form is a programme followed step by step'[3] (Schiele, 1987, p. 64). School is for an audience consisting of homogeneous, captive groups and has certain levers of enforcement. Students 'are all required to attend the lessons they are enrolled for and, ideally at least, to tackle their difficulties with a comparable degree of preparation' (Schiele, 1987, p. 64).

Does that mean that the dissemination of knowledge is solely via school? No, the question is absurd. Formal education is first and foremost linked with the working of the social recognition conferred by degrees and diplomas (Jacobi & Schiele, 1990).[4]

Conversely, non-formal education (in this case the communication of scientific and technological information) is free to choose both the subject and the way it is handled. So it can take its cue from current events (Guéry, 1985), with a penchant for medical subjects (Krieghbaum, 1968) and, more recently, environmental topics (Schiele et al., 1991). The object is not to organize information to suit the internal coherence of disciplines or a structured programme but to satisfy the latent or evident expectations of the target public (Wiebe, 1964, Boy & Muxel, 1989). Non-formal education can also make its aim—and unhesitatingly does so—to entertain as well as to inform (Schiele & Larocque, 1981) and to arouse emotion or inspire dreams (Jacobi & Schiele, 1988). The public is neither captive nor homogeneous: 'It only exposes itself to the message if it so decides' (Jacobi & Schiele, 1990, p. 85).

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The communication of scientific information denotes a range of social practices

What is more, the ways in which scientific and technological knowledge is communicated are many and various and include every form of modern communication: writings, books, the audiovisual media, exhibitions, radio and television programmes and, soon, multi-media packages.

The supply of scientific and technological information products is therefore highly diversified as are the many related activities: scientific clubs, scientific leisure activities, nature trails, science passports, scientific sponsorships, open days, etc. This wide range of media tends to make scientific and technological culture a very general and confused expression, ill-served by its vague objectives (both to inform and to entertain) and boiling down to no more than the combination of all the media it uses. In particular this robs it of all meaning. It needs to be understood that scientific and technological culture is not a specific form of communication as compared, for example, with communication by teaching, even though it does favour certain specific situations of communication and certain—now well-known—modes of reasoning which make it specific (Jurdant, 1973; Mortureux, 1983; Jacobi, 1984, 1987).[5]

Since scientific and technological culture uses all information media to convey messages of different form and content to publics of differing expectations and in different reception conditions, what we call the dissemination of scientific and technological culture embraces a wide range of social practices. There is not one practice for the non-formal dissemination of science and technology but several, a fact which has a direct impact on the nature of information products and on the relationship that the public has with them.

So, to consider the dissemination of scientific and technological culture solely from the angle of the media is highly limiting. The communication media and social processes used in the divulging and transfer of knowledge are more complex than is commonly and spontaneously thought.

THE SUPPLY OF SCIENTIFIC AND TECHNOLOGICAL CULTURE

There is no comparison between the way television operates in this area and what happens in a science club. The creator of a commercial product in the field of scientific and technological culture has to perceive a market for it and be sure that the product will be consumed. It is fair to ask whether products of scientific and technological culture meet the needs of training or culture or whether, instead, they are imposed by those groups having sufficient resources to launch them.

Dinosaurs, for example, certainly fantastic creatures, epitomize in themselves the subject of otherness—which is why they fascinate. Beloved of popular authors, they occupy a disproportionate place in productions for children (books, toys, television programmes, films, etc.) compared with that accorded to other forms of life. The film *Jurassic Park* was accompanied by a range of derivative products (books, tee-shirts, clothes of all kinds, cuddly and other toys, etc.) designed as much to broaden the commercial reach of the film as to help market it. For our purpose the fact to be noted is that the success of the film, feeding on the fascination with dinosaurs constantly fuelled by a flood of symbolic and commercial productions, had, in its turn, a structuring effect on a whole series of products and subproducts following in its tracks: exhibitions, the 'Dinosaurium' project in Montreal, and weekly encyclopedias, etc. like *L'affaire dinosaures.* Though it is easy to imagine why dinosaurs attract the interest of the public there is no evidence of any explicit public demand. This example shows that the products of scientific and technological culture that are marketed cannot be regarded as a response to an explicit social demand for education. Does that mean that such products are without interest? No. That is not the question because the manufacture of these products, to our way of thinking, is just one of many possible social practices.

The educational activities of a club are in no way comparable with the effects of the products we have just described. The commercial product is based on a structural distancing with intermediaries in between, whereas clubs imply a coming together of knowledge and the practice of knowledge even at the level of familiarization and discovery. Communication in a club depends, ultimately, on verbal exchange and in this way a club is nearer to the teaching-learning relationship in school—which is not the case of the commercial product.

THE QUESTION OF AUDIENCE

The concept of audience or public, to which demand is often related, is more difficult to define than at first appears.

Traditionally, the public is divided up into socio-economic categories and sometimes age groups and these classifications continue to be useful. In recent years however, mainly because of developments in evaluation (Samson & Schiele, 1989), the conditions of cultural practice and its context have been taken into account, a promising approach because it relates social time (leisure time as opposed to working time) with cultural practices recorded in their social context. Examples are tourist visits, family visits to exhibitions, etc. In this way, the conditions in which knowledge is acquired are connected with the framework in which that happens. It has long been known that very often the absorption of knowledge, as of all information, is not the result of direct exposure to the stimulus but passes via an intermediate channel. During a visit to an exhibition, for example, judgements on the information presented stem as much (if not more) from the conversation between the visitors as from the individual's own view of the knowledge required. The extent to which this happens can be seen during scientific and technological cultural visits or activities organized as family or school outings (Niquette & Schiele, 1991). So the way television imposes models, one of its major effects, depends on the way in which the messages conveyed are received: by the family, peer groups such as children, teenagers, old people, etc. Similarly, the limits to the reach of the information material is very clear when it is not a question of multiple reception. These points should be borne in mind in view of the prospect of rapid development of multimedia, hypertexts and hypermedia which, like television and most of the material produced, all encourage individual consumption rather than seeking group assimilation. Conversely, the direct relationship with the seeker or the producer of knowledge reveals all its potential, particularly when one remembers that collective reception has, *de facto*, to do with the group's habitus and ethos. Here the producer of knowledge can go beyond the spontaneous questions raised by the individual cognitive experience of persons and groups (Roqueplo, 1974; Lesgards, 1991).

Table 1 sums up the main characteristics of, and specific differences between, formal and non-formal education.

TABLE 1: A summary of the main characteristics of formal and non-formal education

INDICATOR	FORMAL EDUCATION	NON-FORMAL EDUCATION
Purpose	To train specialists	To educate but not to train specialists
Content of educational relationship	Concerns operations:[6] 'the knowledge of the specialist is primarily a know-how whose linguistic expression is understandable with reference to a practice only by virtue of its underlying method'.[7]	Relates to fragmentary and generally concrete elements: the layman's knowledge is 'a cultural-type accumulation of the results'[8] of the specialist's practice: scientific knowledge that is out of context.[9]
Strategy for the acquisition of knowledge	1. Development of the critical spirit: 'Scientific creativity develops more through the ability to refute theories than through the ability to construct them';[10] The learner's problem is primarily to acquire a formal, experimental or linguistic practice'.[11] 2. Knowledge creates objectivity, i.e. the subject becomes the communicator.	1. The memorizing of knowledge (encyclopedism). 2. The knowledge is made objective, i.e. converted into cultural objects.
Education medium	1. Compose semantic messages designed to establish a graduated, systematic process of qualification. 2. Specialty language.	1. Compose semantic messages that can be assimilated by any person who is educated but not necessarily a specialist nor intending to become one. 2. Layman's language.
Choice of subject	Elaborate system of official instructions (programmes, syllabuses, curricula).	No constraints of any kind.

INDICATOR	FORMAL EDUCATION	NON-FORMAL EDUCATION
Transmission of knowledge	Testing of education efficiency (the purpose of the examinations that qualify the student).	No testing of educational efficiency (the tests, quizzes or assessments which accompany some messages are designed more to call upon the sense of the plausible and the faculty of recognition than that of cognition).
Relation to the discipline	Centred on the internal organization of the disciplines.	Concerned about the real or anticipated interests and expectations of the target audience.
Education conditions[12]	Enclosed, specific space.	Open, undelineated social space—film, newspaper, magazine, television, museum—defining heterogeneous spaces that are abstract because each one is addressed to all and sundry without distinction.
Media used	Generally laid down.	Free choice of media.
Public	Captive: students learn what the teachers are required to teach. Exposure to the message is compulsory for those (pupils, students, adults) who have enrolled for the course of education.	Not captive: an inclination for science or to improve one's education, curiosity, etc. The public exposes itself voluntarily to the message.
Learning time[13]	Not calculated, i.e. determined by the time needed for the learner to present himself as being ready to be tested in the discipline: the time is therefore open and subjective.	Limited portion of leisure (hours, days, holidays); determined by the constraints of the rate of work. The time is therefore closed and subjective.
Supply of and demand for knowledge[14]	1. Mismatch in principle between supply (of knowledge which acts as a constraint) and demand (which resists): reciprocity in the exchange.	One-way relationship with, in the best possible case, a regulating feedback effect[15]: adjustment to suit demand.
	2. Confront each other at the level of knowledge.[16] The demand for knowledge subsumes that for social status.	The learning practice is involved with habitus and ethos.
	3. Space: the reproduction of society.[17]	Space: the commercial relationship between producer and consumer.
	4. From the unknown to the known and, in its advanced forms, from the known to the unknown (training in research and research itself).	From the unknown to the known. The receiver is brought back to knowledge which is already there.

There has to be a consensus

In the present context, non-formal education has to supplement the role of the school whenever the latter fails to perform its mission of disseminating and sharing scientific and technical culture.

A CHALLENGE: WHAT IS AT STAKE

The challenge to contemporary society and what is at stake there resides in the ability to develop within society a true scientific and technological culture. The members of society have to be able to make ethical, strategic, ecological, economic and technological choices in full possession of the facts. This is necessary for the healthy exercise of democracy and for the maintenance of economic health in an increasingly complex environment and an increasingly competitive economy (Pouzard, 1989). The vast amount of literature on the scientific and technological culture all spell out the forms of this consensus (Schiele, Amyot & Benoit, 1994). [18]

This consensus is far from new. It grows in strength as each new scientific and technological advance has increasing influence on science, know-how, thought and life-styles (Papon, 1989; Barré & Papon, 1993). Because of this, the social stakes of the growing integration of scientific, technological and economic development are also rising, furthering the demand for greater co-ordination in government measures so that they should both favour development and at the same time safeguard welfare and equity.[19] This comes out in successive recommendations by the Organization for Economic Co-operation and Development (OECD, 1963; OECD, 1971; OECD, 1980).

For some authors, the need for scientific and technological culture to be developed stems from the 'increase in the value to society of science and technology' and an 'understanding of the importance to society of economic development (Pitre, 1994, p. 8-10). This is due to the present form of the consensus that has imposed itself over the last 15 years. It is true that the increasing role of science and technology in the formation of contemporary society heightens and in some cases exacerbates tensions and contradictions and may bring about a structural break. For these reasons OECD argues that innovation must not be solely technical but socio-technical as well (OECD, 1980, p. 93 et seq.), the conclusion being that raising the level of education will guarantee better adjustment to technological change and allow the nation, in the long term, to build up its comparative advantage. In addition, so the argument goes, the well-informed citizen's participation in the debate will improve the decision-making process.

There is no point in taking this demonstration any further. The thinking is central both to the search for a new social and economic order and to the imposition of a social contract. Even its criticism and rejection take place within the space it itself delineates and circumscribes. They are evidence, *a contrario,* of its structuring effect.

It has to be stressed that this consensus, and its criticism, has deep-reaching historical roots. In the 1960s, when there was no talk of scientific and technological culture but only the popularization of science, it was expressed in similar terms.[20]

The instability of the wording used has acted as an obscuring screen. 'Scientific and technological culture', 'popularization of science', 'public communication of science', 'scientific vulgarization', 'science literacy', 'public understanding of science', etc.[21] (Fayard, 1988; Rovan, 1973; Giard, 1979; Schaeffer, 1986; Guédon, 1981; Lucas, 1987) are all so many ways of describing the same process at work in different cultural and historical contexts. But none succeeds in describing it correctly. What is more, the process is probably very different from the ideological function that the variants in the consensus would like to assign to it.[22] This instability is the sign of a vague social demand emanating from different and separate sources. It is not possible to give scientific and technological culture a single social place and space broken down by age-groups or socio-economic categories.

THE IMPLICATIONS OF THE CONSENSUS

The resurgence of the consensus always features in a line of argument pointing to the quickened rate of industrial and economic change and, nowadays, their social consequences, and calling for a revolution in thinking and skills in order to keep up the pace—which also means solving the tensions and contradictions that these changes generate.

As a result, school is at the centre of the argument: sharply criticized for dropping behind, it needs change in order to adjust promptly to the requirements of the new realities. Scientific and technological culture is recruited in support to make up for the immediate shortcomings of the school and to inject new energy into it. It is seen as both an aid to, and vector of, change.

This reasoning wrongly dissociates school from the general movement of culture and, in the specific case with which we are concerned, isolates the teaching of science from scientific and technological culture, as if science and culture existed in different universes; scientific and technological culture is presented as being outside school. Yet it would seem more fruitful to seek out their points of synergy because, as Bourdieu and Passeron showed (1970) neither school nor culture is sufficient in itself. Ethos and habitus strengthen or oppose, as the case may be, the work of the school, which dispenses explicit knowledge but relies on implicit knowledge (Chevallard, 1985). It is subtly linked with the input from the family circle and cultural practices, modulated by the ethos and formal learning. Since the scientific and technological culture of non-formal education occupies the same space of reasoning as that of formal education, and since each anchors and actualizes its own reach, the question of their specificity and dialectic is hardly hinted at.

Notes

1. Guy Barbichon, 1973, *passim.*
2. It is useful to draw a distinction between knowledge and information. We would agree with Durand (1981, p. 81) that there is no 'difference in the nature of knowledge and information; information is circulating knowledge and information is accumulated information'.
3. 'The primary characteristic of formal scientific education is that it is wholly regulated by a system of official instructions, defined by programmes or syllabuses and organized in a series of curricula in accordance with the place assigned to science in the general or vocational education system. [. . .] Success or failure in formal education is expressed in the form of degrees or access to a higher level. The official aims assigned to scientific education are reflected in the recognized instruments certification and everyone knows the extent to which educational content is neglected, being neither assessed nor taken into account when degrees are awarded' (Jacobi and Schiele, 1990, p. 84-85).
4. For lack of space, we deliberately confine ourselves to just two aspects. Obviously a deeper analysis would need to include the vocational training and retraining provided by firms and private or government agencies. More attention would also have to be paid to the dissemination of scientific and technical information and the resources it now has. Along the lines of our argument it would be easy to show that training and retraining come under the heading of formal education though without the legitimacy that only the official education system can confer, while the dissemination of scientific and technical information, including the systematic methods of technology alert currently being developed, are part of non-formal education.
5. The number of studies made on the linguistic processes for the non-formal dissemination of science is considerable but, since it is not the purpose of this article to present even an incomplete round-up, the reader interested in these questions could refer to the summary paper entitled *La vulgarisation scientifique et l'éducation non formelle* (Jacobi and Schiele, 1991).
6. Which does not rule out—on the contrary—a gradual progression in information and thus, precisely, reaching the operations: 'knowledge of special data, knowledge of the means enabling special data to be used, knowledge of abstract representations', etc. (Bloom, 1975).
7. Jurdant, 1973, p. 57.
8. Ibid..
9. Schiele and Larocque, 1981.
10. Jurdant, 1973, p. 70.
11. Jurdant, 1973, p. 58. We might add: knowledge 'is what may be spoken about in a discursive practice specified thereby [. . .], knowledge is also the field of the co-ordination and subordination of statements where concepts appear and are defined, applied and transformed [. . .]'. To acquire scientific knowledge is to master the 'coherent handling of terms and formalisms, the whole of which constitutes the discourse of a science' (Foucault, 1969, p. 238).
12. Jurdant, 1973, p. 70-71, *passim.*
13. Ibid.
14. Ibid.
15. Moles, 1967.

16. Which does not, of course, rule out the search for social status and convergence between the demand for degrees and the interests of society (Jurdant, 1973, p. 69, *passim*).
17. Bourdieu & Passeron, 1970.
18. 'The modern world sees the advent of a scientific and technological culture, shared by all strata of the population, as one of the strategic factors of the integration of the individual in an increasingly complex society. In the constant changes they bring about in relations with the world and others, science and its achievements require that, to be a citizen in the full sense, everyone has to be able to participate in the debate on the future of our society or, at very least, understand what is implied. What is at stake is our democratic responsibility.

    'The modern world makes the dissemination and sharing of scientific and technological culture one of the conditions for winning competitive edge, building economic recovery and maintaining the prosperity of the nation. Swift adjustment to scientific, technical and industrial change, the key to improved competitive capacity, is only possible with new skills based on the understanding and mastery of the basic principles of science and technology. What is at stake here is economic competitive capability.

    'The modern world regards the monument erected by science as one of the greatest achievements of the human mind, with scientific and technological culture thus taking its place alongside music, literature and the fine arts. Here what is at stake is recognition of the intellectual accomplishment of science and technology.

    'Lastly, the modern world also posits that the contemporary expression of rationality requires the assimilation of the reasoning processes inherent in scientific and technological culture, the need for which arises first and foremost in school, which is expected to pass on the values and abilities on which our modernity is built. Here, what is at stake is the quality of the joint and individual decisions and choices that determine the present and the future' (Schiele et al., 1994).
19. Needless to say, OECD's reports have repeatedly drawn attention to the problems that governments should address, namely pollution and the deterioration of the environment, the widening gap between the haves and have-nots, the deterioration in the employment situation, deskilling and so on, but do not arrive at the conclusion that scientific and technological development has to be halted. 'We start from the premise that advances in science and technology and their embodiment in investments and labour skills are a necessary though by no means sufficient condition for dealing with the problems now facing the world' but 'technological progress must take place in a way which is compatible with an increasing demand for democratic governance and equity at all levels—in the community, in the work place, in the nation-State and among nations' (OECD, 1981, p. 91-92).
20. On this point, cf. Le Lionnais, 1958.
21. As we have already said, there is no shortage of terms used: 'vulgarisation des sciences', 'popularisation des sciences', 'divulgation des sciences', 'communication des sciences', etc., in French and 'science literacy', 'public understanding of science and technology', 'public awareness', etc., in English.
22. To be brief we would say that the Canguilhem viewpoint (1955) is by far the richest: it is more important to follow the filiation of concepts than the chain of theories, in other words to go from the concept to the theory, not the reverse. Defining a concept is formulating a problem: 'the continued presence of the concept, all along the diachronic line that constitutes its history, proves the permanence of the problem' (Lecourt, 1972, p. 78).

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NEW MODELS FOR THE LEARNING PROCESS: BEYOND CONSTRUCTIVISM?

André Giordan

When we observe the teaching or mediation of science, three main traditions may be discerned. The first tradition, which is the most widespread and long established, is founded on the idea of frontal transmission of knowledge. Each stage in the process introduces specific subject matter, taken from a syllabus or table of objectives, that in sum makes up the knowledge to be acquired. In this type of teaching or mediation there is a linear relationship between the teacher, the repository of a body of knowledge, who delivers an increasingly often illustrated lecture, and the pupil on the receiving end. In museums, this tradition is reflected in a 'bookish' presentation or in the presentation of a 'medium'. In every case a 'person who knows' pours out a predetermined package of knowledge to a passive listener. At school, this transmission of information is reinforced by a corresponding effort of memorization.

The second tradition, developed since the 1950s, is based on a training process upgraded to the rank of learning principle. The chosen propositions are of the stimulus-response type, and faith is pinned on ideas of 'conditioning' and 'reinforcement'. The teacher, or most commonly the programme designer, analyses the behaviour, the chaining of which expresses the skills to be acquired. He or she then devises questions capable of bringing those skills into the open and couples the replies of the pupil with approving or disapproving reinforcement stimuli. In practice, this tradition takes the form of teaching through exercises. In museums, it is reflected in the widespread 'push-button' trend. Programmed teaching of this sort has been given a new lease of life with the development of computers.

Lastly, the third tradition, of more recent origin,[1] corresponds to what is generally called 'the discovery method' or 'learning by construction'. It responds to the spontaneous needs and interests of the pupils; it advocates their freedom of expression, creativity and life skills; it highlights independent discovery and the importance of proceeding by trial and error in a process of construction initiated by the pupil. In

A biographical note on André Giordan appears on page 23.

theoretical terms, the construction of knowledge is achieved by giving a major role to pupil activities, a somewhat debatable approach in practice.

Psychological presuppositions

It is interesting to find that each of these positions in general refers back to an emblematic psychological theory. Do there exist constants in human thought? The pedagogy of transmission has been based on empiricism throughout a long tradition dating back to Locke (1693). The second approach was founded by behaviourism (Holland & Skinner, 1961; Skinner, 1968). The third one developed as part of constructivist psychology. Actually, we should speak of constructivist theories in the plural, since constructivism had a number of variants: some writers stressed associations (Gagné, 1965, 1976; Bruner, 1966), others 'cognitive bridges' (Ausubel et al., 1968), and yet others 'assimilation and accommodation' (Piaget & Inhelder, 1969; Piaget, 1971), co-action (Doise et al., 1975, 1985; Perret-Clermont 1979, 1980) or interaction (Giordan, 1978).[2]

For Ausubel (1968), for example, everything is a question of linkage, which is facilitated by the existence of 'cognitive bridges' that render the information meaningful in relation to the existing overall structure. For him, new knowledge cannot be learned unless three conditions are met: first, the availability of more general concepts that are gradually differentiated during the learning process; second, a system of 'consolidation' to facilitate the understanding of ongoing lessons, since new information cannot be introduced as long as the preceding information has not been mastered. If that condition is not met, the entire learning process may founder. Lastly, the third condition—'integrative conciliation'—consists in identifying similarities and differences between the old and the new knowledge, in distinguishing them and in resolving any contradictions that arise. This necessarily leads to readjustments.

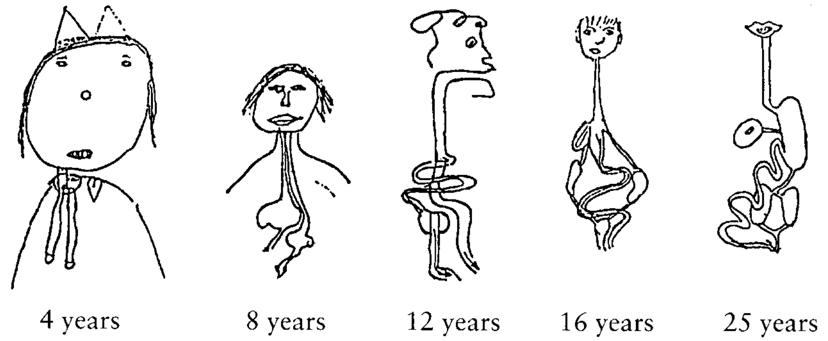
Piaget (1971) also assumes that the pupil deals with the new information in accordance with previously acquired skills and assimilates it. In return, some accommodation is often necessary. As a result, the patterns of thought already in place are transformed to take account of the new circumstances. For Piaget, the aim was to link the new information with what was already known and to graft it onto other concepts by taking account of the 'patterns' available to the pupil.

Contrasting with these three traditions, research is proceeding in a new direction, known as the 'didactics of science', from which new ideas about the learning process are emerging. This approach calls for teaching environments that facilitate at the same time the understanding process, the learning process and the mobilizing of knowledge. It has given birth to new trends aimed at improving the teaching and mediation of science.

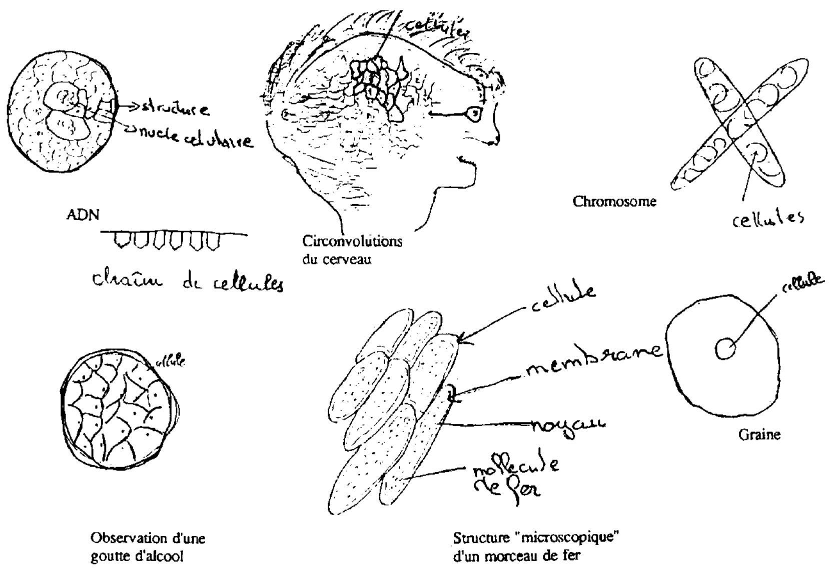
The starting point for this new research direction was a highly pragmatic observation. Why did normal teaching methods, whether of the traditional or so-called 'new pedagogy' type, yield such poor results? Educational output, i.e. the amount of knowledge acquired and capable of being mobilized in relation to the time spent, seemed very low and even nil in some cases. Moreover, a number of 'errors' in reasoning

or 'wrong' ideas appeared again and again in pupils with disconcerting repetitiveness, even after one, two, three or sometimes 'n' lessons on the same subject.
In an attempt to respond to this situation, a series of scientific investigations was begun to describe the processes used by learners and the conditions that impede or

FIGURE 1: Some obstacles in the teaching of scientific concepts

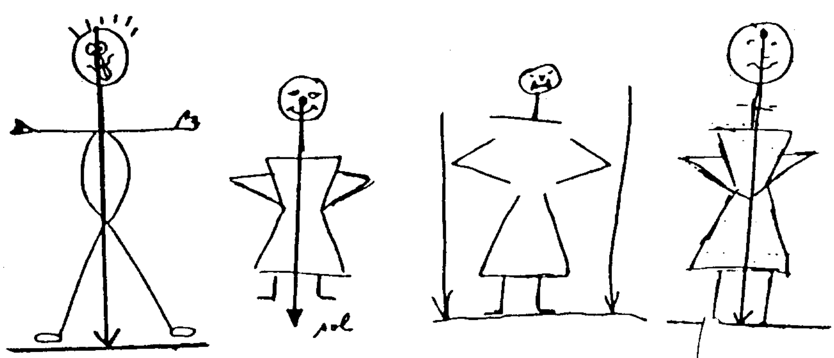


Persistent errors regarding the digestive system



Different interpretations of the term 'cell' by pupils from 10 to 20 years old

Continued



Difficulties encountered in teaching the concept of gravitational force

These 16-year-olds have learned that the 'gravitational force' or 'weight' should be represented by an 'arrow' indicating its orientation, direction and magnitude. What they have understood (intuitively) is that this force, represented by a 'vector', acts vertically in relation to the body. However, they do not take into account all significant factors: the force may be applied at more than one site and not necessarily in relation to the centre of gravity—a concept that is not understood and thus difficult to use. Above all, the drawings show that the force must necessarily 'reach the ground'; this aspect is particularly interesting, because it shows that the Newtonian idea of attraction from a distance is far from having been assimilated.

favour those processes. This research has resulted in models that are now challenging the cognitive sciences.

Contributions to the teaching of science

Constructivist models no longer see the learning process as the result of impressions left in the pupil's mind by sensorial stimulations emanating from the teaching, like the effect of light on a photographic film. It is quite rare for the mental structure of a pupil to be spontaneously in tune with that of a teacher, even if the teacher has done his or her job well and the pupil has been listening carefully; in any event, it never happens immediately. It occurs only in very special cases, when the teacher and the learner ask themselves the same type of questions and possess the same type of references. In fact, such a situation arises mainly between peers or where the information in question is very commonplace.

The organization of a learning process or the structuring of knowledge stems at bottom from the activity of the subject. Learning thus becomes a capacity for effective or symbolic, physical or verbal action. This capacity depends on the existence of mental patterns resulting from the action. The latter are engendered by the active repetition of behaviour that, when concerned with picturing realities or abstractions, reconstructing them and combining them in thought processes, plays a fundamental role.

Unfortunately, the constructivist models appear rather primitive in actual teaching or mediation. Our pedagogical research shows that the learning process covers a number of multiple, polyfunctional, 'contextualized' activities. There is very little in common between learning the number of sepals and petals in a flower—a process that in practice only involves relating the two followed by straightforward memorization—and learning population genetics, which relies chiefly on a highly abstract deductive approach and on the concept of regulation, which necessitates a change or paradigm.

Similarly, this research reveals that the learning process mobilizes several levels of mental organization, apparently quite different at first sight, as well as a considerable number of self-regulation loops. To want to explain everything within a single theoretical framework is rather a tall order, especially as the various constructivist models have been developed in highly simplified contexts. If we take the learning of the concepts of energy, particle structures or genes, for example, the process does not depend on cognitive structures as defined by Ausubel or Piaget. Subjects who have attained high levels of abstraction may reason out new subject matter in the same way as young children. It is not only an operational level that is being questioned, but what we call a global conception of the situation, which embraces simultaneously a type of self-questioning, a frame of reference, signifiers and semantic fields, including metaknowledge on the context and the learning process, etc. All these elements influence the way of thinking and learning and are passed over in silence by the constructivist theories.

Similarly, the assimilation of scientific knowledge does not take place solely through 'reflective' abstraction. In learning to handle subjects such as systemic analysis or modelling, abstraction may distort the process. In most cases it causes a radical shift: a new factor seldom fits into the sequence of previous knowledge, and thus that knowledge often represents an obstacle to its integration. Wanting to explain everything in terms of 'cognitive bridge', 'assimilation' or 'accommodation' is over-ambitious. A process of deconstruction needs to take place at the same time as any new construction process; the latter then becomes preponderant.[3]

To enable learners to understand a new model or mobilize a concept, it is necessary to transform their whole mental structure. The framework of their questions has to be completely rearranged, and their web of references to a large extent reworked. These mechanisms never take place at once but need to go through phases of conflict or interference.

Lastly, the various constructivist models say nothing or almost nothing about the social or cultural context of learning processes. They do not allow us to deduce the consequences of situations, resources or environments that foster the act of learning—which is to be expected, since that is not their initial concern. At the most they put forward the idea of 'maturation' or 'regulation' without specifying the conditions for such activities in actual practice. In 1989 Vinh Bang noted with regret that 'a psychology of the pupil was still lacking'.[4] In reality, it is the whole psychology of learning that remains to be worked out. But is this still psychology in the traditional sense?

The conceptions of learners

Research on the conceptions of learners has shed new light on the question of cognitive learning processes. The specialist in teaching methodology began by characterizing the 'representations' as a gap between the learners' thinking and scientific thought. The term 'misconception', widely used in English and American research (for example Novak, 1985, 1987) is significant. Since then studies on the subject have forged ahead and, among specialists, the term 'conception' has replaced 'representation' (Giordan & de Vecchi, 1987).

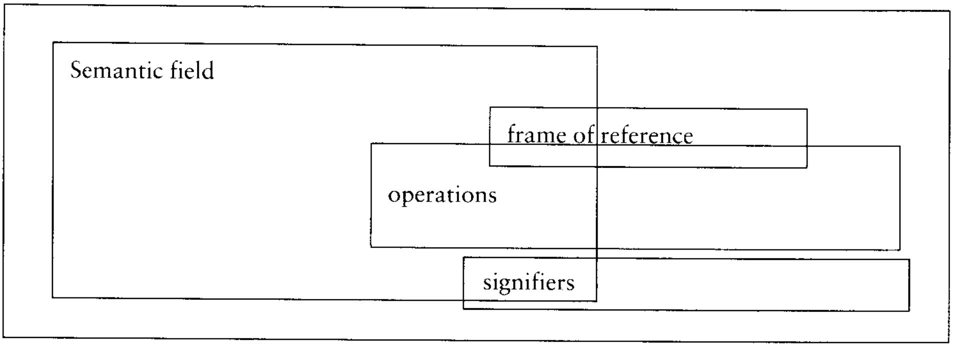
Nowadays it is considered that conceptions play a role in the identification of the situation, in the selection of pertinent information, in the processing of that information and in the production of meaning. According to the authors, they appear as 'tools', 'levels of operation' and 'thinking strategies' and are the only means available to the learner to apprehend reality, the subject matter of the teaching or the information content (Novak, 1984, 1985; Host, 1977; Lucas, 1986).

Conceptions are interpreted less as components of a stock of information stored for subsequent use than as 'a kind of decoder' by means of which the learner is able to understand the world around him or her (Simpson et al., 1982; Osborne & Gilbert, 1980; Osborne & Wittrock, 1983; Osborne & Freyberg, 1985). In consequence, they are of considerable importance in teaching and mediation. They open the way, it seems, to the tackling of new issues, the interpretation of situations, the resolving of problems, the provision of explanations and the making of forecasts. It is by their means that the learner will select information, give that information a meaning—possibly in conformity with the scientific knowledge of reference—understand it, integrate it and hence 'understand, learn' (Giordan & de Vecchi, 1987; Driver, Guesne & Tiberghien, 1985) and mobilize knowledge (Giordan, 1994).

CHARACTERISTICS OF CONCEPTIONS

Conceptions are always anchored in questioning. They appear to exist only in relation to a problem which may be implicit. Once framed, the conception frequently leads to reformulation of the problem. In addition, the conception is determined by four other interacting parameters, namely the frame of reference, the operational constants, the semantic field and the signifiers.

FIGURE 2: Characteristics of conceptions (Giordan, 1987)



The frame of reference comprises all the previous integrated knowledge, which, when assembled and activated, gives a shape and a meaning to the conception. This frame leads the learner to ask himself or herself direct questions and provides the context (information and other conceptions) that explains the production and presentation of the conception.

The operational constants comprise all the underlying mental operations that establish relationships between the elements of the frame of reference, make the conception function and if necessary transform it on the basis of newly recovered information. It is also these constants that regulate the conception by interacting with the frame of reference.

The signifiers are all the signs, traces, symbols and other forms of language (natural, mathematical, graphic, diagrammatic, modellized, etc.) used to produce and explain the conception.

Lastly, the semantic field is the web of meanings deduced from the preceding elements. Its nodes represent the frame of reference, and its linkages may be equated with mental operations. It is through that field that the meaning of the conception emerges.

HOW A CONCEPTION FUNCTIONS

There are several aspects to a conception: informational, operational, relational, dubitative and organizational. One discernible function is conservation of a piece or body of knowledge, including practical knowledge. Such memorization is not direct but shaped by integration into a structure. A conception organizes information and stands as the trace of previous activity.

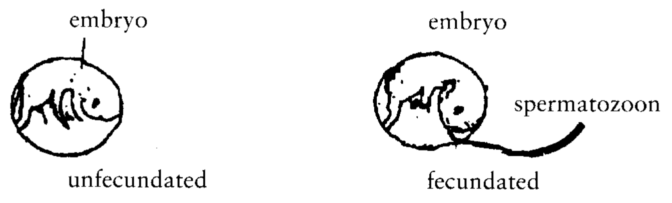
This function, however, cannot be likened to a mere memory. The structured and conserved information is subsequently re-used in new situations. The conceptions are transformed by the situation that activates them, being continually reshaped in order to be 'in phase' with the new context.

Conception thus makes recall possible but is primarily concerned with identifying the situation and selecting relevant information. Events, context and perceived

FIGURE 3: Different conceptions about fecundation and the making of a baby (children from 10 to 12 years old)

On the subject of fecundation, three types of response may be discerned among learners.

Type 1. Certain learners think that a baby is made by the mummy, either alone or with the indirect help of the daddy. For them the important thing, the thing that will produce the 'baby with all its traits' or 'the seed', is produced by the mother; it is generally located in her belly or ovum. The father has no role or simply an indirect one: he either fecundates the mother in a general way, who is then able to make children, or, more precisely, he provides the sperm (or spermatozoon) which acts simply as a stimulant that triggers the 'development' of an 'already formed baby'. The seed of the baby is in the ovary, which is commonly confused with the ovum. It is in a cavity; the sperm enters the cavity and gives the baby life.

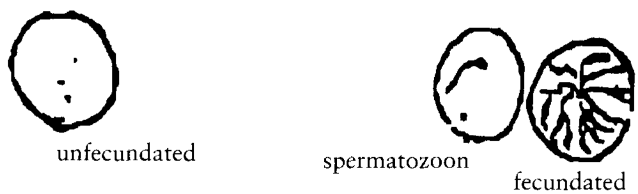


Type 2. In contrast to the preceding idea, other learners say that the baby is made by the father, who provides the sperm or spermatozoa (we find numerous confusions between sperm and spermatozoon, the latter word also being spelled in many different ways). The spermatozoon (or sperm) thus becomes the important factor. For most pupils, the ovum, when it exists, serves as a feeding place and haven which fosters the development of the child 'already a seed' or 'germinating' in the spermatozoon.

The father injects the spermatozoa, which contains the child; the mother provides the ovum. The spermatozoon seeks out the ovum in order to obtain food and develop. The egg will produce the baby.

Type 3. For still other children, the baby is made by the father and the mother, each providing something. The father contributes the sperm or spermatozoon (with the many kinds of confusion already referred to above). For the mother, the decisive factor may be the ovum (or ovary) but also a 'substance' such as 'her period', 'vaginal discharge' (or 'secretions of the vagina or womb').

The child is formed from the sperm and the woman's liquid; 'the two liquids are mixed together and produce the baby'. Lastly, some children bring in the spermatozoon and ovum and even put forward the idea of an input of 'information' or 'hereditary traits'. When the spermatozoon and ovum are in fact given a complementary role and regarded as the vehicles of hereditary traits, we find that many pupils use a specialist vocabulary ('chromosomes', 'DNA', etc.) but rarely in an operational manner; they may even employ terms such as 'hormone' or 'neuron' as synonyms of 'chromosome', etc.



'The spermatozoon and the ovum combine their hereditary traits. The spermatozoon approaches the ovum and penetrates it, and the ovum becomes a baby'.

messages feed in external elements (new information) and activate internal ones (memorized knowledge). Their importance in knowledge construction mechanisms is apparent: the acquisition of a piece of knowledge signifies advance from a previous conception to another conception that is more relevant to the situation.

A second important function is the constitution of relationships and even systematic arrangement. The individual is constantly seeking, at least when he or she is personally concerned, to regroup all the elements of the knowledge at his or her command in a field or with respect to a particular question. However, the relationships observed are in most cases incomplete or disparate in comparison with those established in a scientific framework.[5]

Lastly, conceptions structure and organize reality. They are applied to situations so as to enable the learner to raise problems, carry out various activities, conceive new methods of procedure to be applied, and so forth. They are the signs of a model and of a comprehensive method of approach in response to a problem area. They are in fact cognitive strategies that the learner implements in order to select pertinent information to structure and organize reality. They refer back not only to the elements the learner will mobilize directly in order to explain, foresee or act but also

FIGURE 4: Mobilization of conceptions

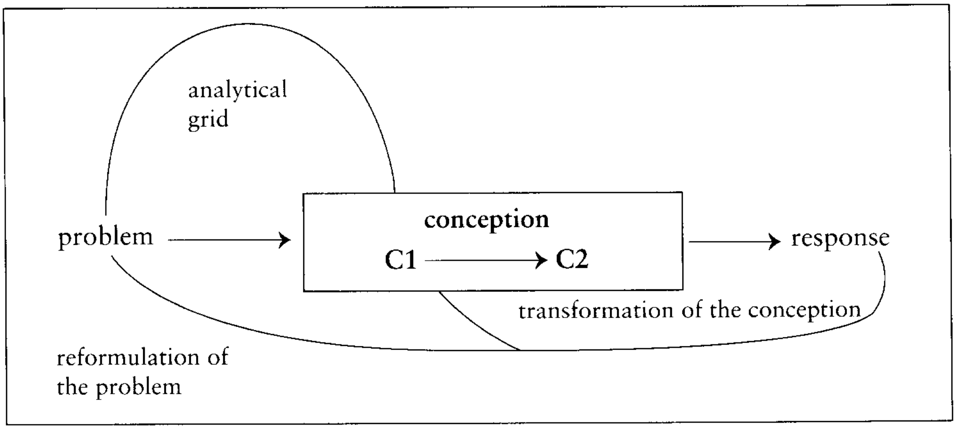
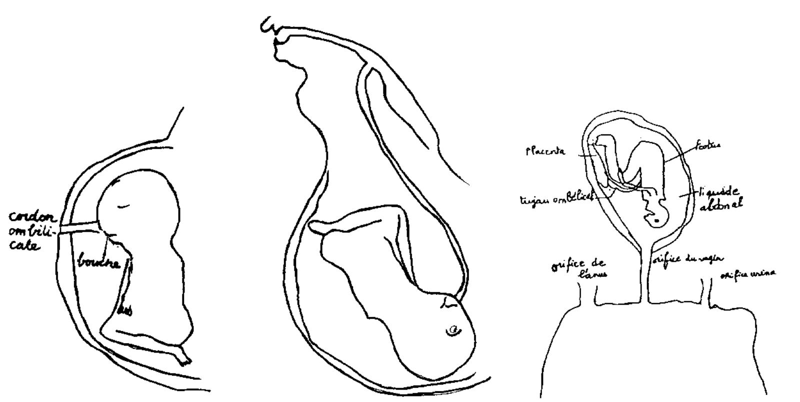


FIGURE 5: Decoding obstacles by using the allosteric learning model grid

When we analyze the conceptions of children on the life of a baby in a 'mummy's tummy', we are struck by a number of their statements and drawings. Even very young children picture to themselves 'what it is to live'. They have built up an idea about what breathing means and also know what eating means—or at least they think they know because of their own daily experience. These ideas will lead them to ask themselves questions. And it is also in relation to such ideas that they will reason out their answers.

1. How does a baby breathe? For a child, breathing is ventilation, that is to say making air come in and then go out. This air can only be 'gaseous'. The baby must 'take air from the air'. The child then often imagines a tube going from the mouth of the mother to the mouth of the baby or from the mouth of the mother to the lungs of the baby, possibly passing through the umbilical cord.



Some conceptions of the respiration of a foetus by children 8 to 12 years old

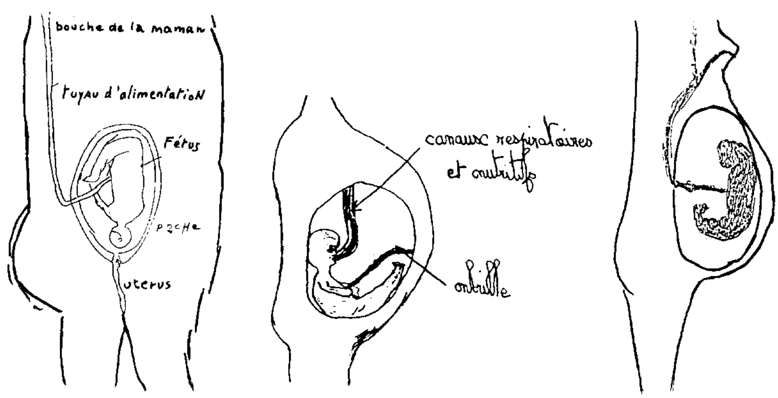
to the individual's personal history, including his or her ideology, social stereotypes and even fantasies.

Conceptions must therefore not be interpreted as accumulations of past information or parts of a stock of information simply stored for subsequent consultation. They represent first of all a mobilization of known elements for the purpose of explanation, questioning, prediction or the carrying out of a simulated or real action.

In this mobilization, based on the pupil's experience in the traditional sense, the learner builds up an 'analytical grid' of reality, a sort of decoder that will enable him or her to understand the surrounding world, tackle new problems, interpret new situations, reason through a difficulty and come up with an answer that he or she thinks provides an explanation. It is also on the basis of this 'tool' that the learner will select information from outside for possible inclusion and integration.

If the children know in addition that the baby lies in a 'cavity containing liquid', they will solve the problem of respiration by putting a tube that collects air directly from the mother's navel 'in order to breathe air from the air'. In this case, the frame of reference used is that of 'an underwater swimmer with a breathing tube'. Or they might imagine an opening in the vagina and womb to allow the baby to breath directly.

2. How does the baby eat? Eating is essentially taking in solid 'things'. How can the baby do this? By means of a tube which starts from the mother's mouth and goes to the baby's or starts from the mother's mouth or breasts and goes to the umbilical cord.



Some conceptions of foetal nutrition by children from 8 to 12 years old

Models of the learning process

The learner's conceptions thus lie at the heart of the learning process. They are involved in the various interrelations existing between the information, operations and processes available to an individual and those that individual will come across throughout life. On these elements he or she will build up new knowledge and in doing so shape his or her future modes of conduct.

At this point the research into teaching methods came up against a major problem: how can a teacher 'utilize' the conceptions of learners in his or her teaching practices? Should he or she help the learners to enrich their conceptions and/or displace them? Should he or she imperatively begin by refuting them? Can he or she transform them? And if so, by means of what teaching strategy and with what teaching aids?

THE ALLOSTERIC LEARNING MODEL

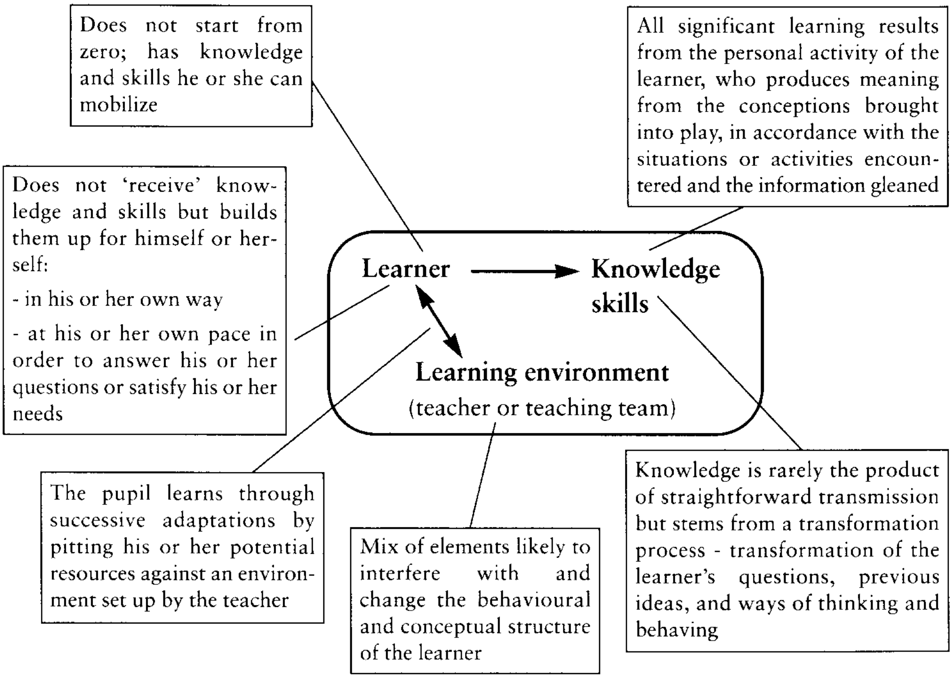
In the face of the marked shortcomings of constructivist models in this area, various teaching models have been suggested. One of them, known as the allosteric learning model, conceived by Giordan and de Vecchi (1987) and developed by Giordan (1989), has aroused international interest. It allows a series of conditions conducive to the generation of relevant learning processes to be inferred. Indeed, it is precisely that aspect, known as the learning environment, which is most frequently made use of.

When applied to specific bodies of knowledge, the allosteric learning model first of all makes it possible to decode the processes, grouped under the customary terms of understanding and learning, in the form of entities of a systemic and multistratified nature. The self-regulation loops and levels of integration are highlighted and, at the same time, the various obstacles are ironed out and explained.[6]

At the functional level, this model tends to reconcile the paradoxical and contradictory aspects inherent in any learning process. All knowledge that has been mastered is both an extension of previous knowledge, which provides the framework for questioning, references and meaning, and is at the same time a discontinuity with that knowledge, at least by diverting or transforming the questioning. One learns 'thanks to', as Gagné writes, 'on the basis of' (Ausubel) and 'with' (Piaget) but also 'against' (Bachelard) the functional knowledge in the 'head' of the learner. The model shows that learning is a matter of approximation, interest, confrontation, decontextualization, interconnection, discontinuity, alternation, emergence, threshold, detachment and above all mobilization.

In point of fact, the allosteric model reveals that the success of any learning process depends on a transformation of conceptions. All knowledge acquisition stems from complex formative activities: the learners match the new information with their present knowledge, now mobilized, and perceive new meanings that come closer to answering the questions or problems glimpsed. They then create for themselves what we call 'active conceptual sites'; these are like interaction structures and play a

FIGURE 6: Important ideas about the learning process introduced by the allosteric model.



leading role in organizing the new information and developing the new conceptual network.

Such a process is never simple; neither is it neutral where the learner is concerned. It could even be considered a disagreeable process. The conception mobilized by the learner provides him or her with an explanation, and any change is perceived as a threat because it changes the meaning of past experience. The conception serves as both an integrator of and a powerful resistance to any new fact that contradicts the established system of explanations. Furthermore, the learner has to exert deliberate control, at various levels itemized by him or her, over his or her activity and the processes that govern.

A TEACHING ENVIRONMENT

Apart from the description of cognitive strategies,[7] the main contribution of the allosteric learning model is of a pedagogical nature. It shows that only the learner is able to learn and that he or she cannot do it alone through his or her own mental structures. This approach can be considerably enhanced by an interactive series of parameters, called a teaching environment, placed at the disposal of the learner.

Between the learner and the knowledge-object, a system of multiple interrelations has to be established. This system never arises spontaneously; it is highly impro-

FIGURE 7: Use of the allosteric model for the concept of circulation

Teaching the concept of blood circulation in a primary or lower-secondary school is by no means straightforward. To get across the idea that the blood circulates has no 'meaning' in itself, especially when a child is not all that sure what the word 'circulates' means. It is clear at present that the message is not getting across. The tools provided by the allosteric learning model show that the main obstacle is the absence of questioning. As a result the information offered has no meaning for the learner.

1. The question of **nutrition** could be a possible motivation for approaching this concept. Body organs or cells, the choice to be determined according to the group of pupils concerned, need nourishment. How do they obtain it? Pupils quickly realize that organs or cells have no direct access to outside the body. Some process or other must have been established by the living body. At this point blood, with which they are already familiar, can play its part: it becomes the liquid of transport. This conceptual imbalance makes it possible to gain the immediate interest of the pupils. By no means have all the obstacles been overcome, however. The children still have to be convinced that nutrition involves all the cells or all the organs and is not a general function of the organism as a whole: 'one eats to live'. At this level, it is necessary to take one's time to argue the case.

2. The excretion of cells may mobilize this initial message and reinforce knowledge about **the role of blood.** However, the idea of food intake and the recovery of waste matter does not automatically trigger the idea of circulation in its first meaning of a circle. Historically, a mechanical metaphor, such as the watering of fields, has always been dreamed up. This second difficulty may be overcome if the pupils are asked another question: 'is the blood renewed ceaselessly like water in the countryside? If not, is it always the same?'

   A bit of arithmetic may help: 'About five litres of blood per minute pass through the heart', but 'one cannot make so much blood per minute—especially as that is all one has altogether'.

   This argument shatters the watering model but is not enough on its own to engender the idea of transport in a circle. For this purpose, it is preferable to introduce the model of a circuit. The idea of circulation on its own suggests the idea of traffic circulating in a return journey along the same route. By means of the situations he or she creates, the teacher should, directly or indirectly, spark the idea of a circuit. The pupil's habitual patterns of thinking are indecipherable or block this idea, largely because of the double circulation in which nutrition and respiration are superimposed. There are various ways of getting pupils to look at the matter:

   - show a film of a transparent alevin in which it is possible to see, thanks to the red corpuscles, the more straightforward blood circulation of fish;

   - imagine the continuity of arteries and veins and think about what happens in the organs (use classwork on capillaries);

- construct dynamic models that display the route taken by the blood, with a pump, organs and various tubes and find visible ways of showing the functions of each component of the system.

In exhibitions, the use of balls that move about under changing lights or that change colour because of the temperature may help pupils visualize the changes in the blood in internal organs and lungs. In the classroom, a model of this kind can be built with odds and ends. This constitutes a practical introduction to modelling. Pencil and paper models can also be successfully made by the pupils.

3. The idea of food can be brought up again and mobilized to explain **respiration,** another subject that it is easy to get pupils interested in. 'It is necessary to supply oxygen' to the organs or cells. In this case, however, certain pupils have a powerful obstacle to overcome: respiration is not just a question of the lungs. They also have to grasp numerous relationships:

- food + oxygen → energy;

- the body's organs need energy;

- the organs make this energy: use of the car metaphor.

Each step requires explanation and discussion between pupils or the consultation of documents. 'Conceptograms' may help pupils to find their way. But another related problem must be resolved: what can be said about oxygen to get beyond the common idea of a vitamin? When all these elements are fulfilled one obtains another reinforcement by mobilization of knowledge for another situation.

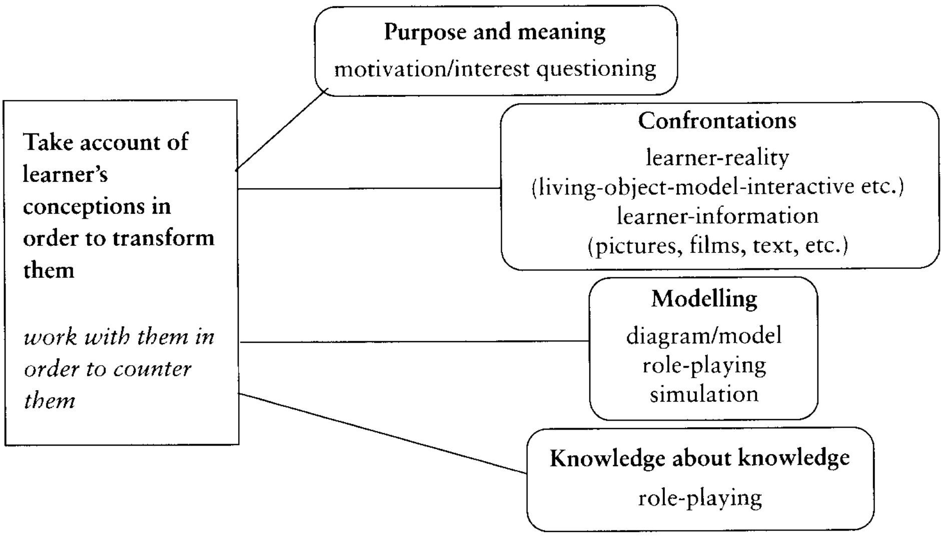
bable that a learner will be able to 'discover' for himself or herself all the elements capable of transforming his or her questioning or of facilitating the establishment of networks.

At the beginning of any learning process, for example, one must be able to introduce one or more 'discords' that jog the cognitive network of mobilized conceptions. This dissonance creates a tension that breaks or displaces the fragile equilibrium achieved by the brain. Only such dissonance can allow progress to be made.[8] Without it, learners have no reason to change their ideas or way of doing things. Similarly, it must also be possible to motivate them or interest them in the teaching situation proposed.

Learners should then find themselves faced with a number of significant elements, such as documents, experiments or arguments, that raise questions and lead them to stand back a little, reformulate their ideas or argue them through. Similarly, a number of simplified formal aids are required, such as symbols, graphs, diagrams or models, that can be integrated into their approach to help them think.

It should be added that a new formulation of what the learner knows will not displace a previous one unless the learner finds it interesting and learns how to make it work. Further exposure to appropriate situations and selected information is a profitable means of mobilizing knowledge in this process. Lastly, some knowledge about knowledge is also necessary. It enables learners to situate their approaches, see them with a certain detachment and clarify the practical relevance of that knowledge.

FIGURE 8: Use of the allosteric model with young pupils



In each case, the allosteric learning model provides tools for decoding the constraints and predicting the situations, activities, interventions and resources that facilitate the learning process.

The allosteric learning model has confirmed a new relationship to knowledge and new functions for the teacher. The latter's importance no longer lies in what he or she says or in his or her introductory demonstrations; the effectiveness of his or her action is always to be found in a context of interaction with the learner's learning strategies. It lies primarily in the teacher's regulation of the act of learning, his/her capacity to arouse interest, and his/her skill at providing pointers for learners' guidance and aids to conceptualization.

Notes

1. This third tradition is always regarded as recent: people continue to call it the new pedagogy. And yet our studies of the history of education show it to be a very ancient approach. Attempts along these lines were already defended by Montaigne and Rousseau and widely explored in the nineteenth and early twentieth centuries.
2. Today it is necessary to add the recently discovered contributions of Vygotsky (1967, 1978) and those of the cognitive science movements.
3. Construction and deconstruction are interactive: the new knowledge takes its proper place when the old knowledge is seen to be outdated. There is a time when they cohabit in different problem areas.
4. Vinh Bang, Introduction, in: A. Giordan, A. Henriques and Vinh Bang, *Psychologie génétique et didactique des sciences* [Genetic psychology and science teaching], Bern, Peter Lang, 1989.
5. Children do not spontaneously relate 'oviparous reproduction' (as with hens) and 'viviparous reproduction' (as in human sexuality). For them, these are two types of mechanism that are strictly different, with no common denominator. In one case procreation is focused on the (highly visible) egg and in the other on the spermatozoon.
6. A learning process never takes place without a series of difficulties that are obstacles to be overcome. These obstacles may be extremely diverse in nature—insufficient information, inadequate mental training, difficulty in carrying out operations, or simply the learners' lack of self-confidence in their ability to handle a problem or find a way forward.
7. The learning process is rather the prototype of a highly complex organized system that cannot be broken down into a few guidelines. It functions more like a jungle ecosystem than a computer, even of the most recent generation!
8. These dissonances are less and less easy to accept when the pupil has much more experience and the subject matter is well known. Any change represents a discontinuity and takes place in a sort of crisis, which may sometimes reach identity crisis proportions when an individual invests everything in what he or she knows and does. The change is smoother when there are signs of a fresh equilibrium in the offing.

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TRENDS / CASES

REDUCING POVERTY IN LATIN AMERICA AMONG INDIGENOUS PEOPLE: AN ENHANCED ROLE FOR EDUCATION*

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The indigenous peoples of Latin America live in conditions of extreme poverty. This paper represents an initial attempt at documenting the socio-economic conditions of indigenous people using empirical data from national survey sources. The nature of the analysis is microeconomic, using household survey data that includes information on indigenous peoples defined in terms of ethnic self-perception, language use and geographical concentration. The countries on which the analysis is based include Bolivia, Guatemala, Mexico and Peru. The aim is to empirically investigate the socio-economic conditions of the indigenous people of Latin America and to identify correlates of poverty. This documentation provides the vital information needed to design strategies for operations and to assist these groups in a poverty reduction strategy. The results point to an enhanced role for education in reducing poverty among the indigenous population of Latin America.

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*The views expressed here are those of the authors and should not be attributed to the World Bank.

Ethnicity is intimately associated with poverty and disadvantage in many developing countries. Given that ethnic inequalities are affected by public policies toward education, employment, infrastructure, markets and affirmative action, then an important challenge is to understand the circumstances, causes and extent of this association. This is the main purpose of the present study, the goals of which are: (a) to determine the extent of poverty among Latin America's indigenous population; and (b) to compare the socio-economic conditions of the indigenous population with the non-indigenous population.

By far the greatest attention paid to the socio-economic disadvantages of indigenous people has been by sociologists and economists exploring the situation of Amerindians in the United States (see, for example, Sandefur & Scott, 1983; Sandefur, 1986; Sandefur & Sakamoto, 1988; Snipp & Sandefur, 1988; Sandefur et al., 1989; Sandefur & Pahari, 1989). Much less is known about indigenous people in other countries, especially in Latin America.

What is known about the socio-economic conditions of Latin America's indigenous people is that they make up a significant portion of the rural poor. These groups live on the periphery in marginal areas, and are often landless. In Latin America, indigenous people make up about 27 % of the rural population (IFAD, 1992). A rural poverty mapping indicates that in eleven of eighteen national cases, the indigenous population is listed among the main groups of the rural poor (IFAD, 1992).

The international literature suggests some priority areas of research, which this study attempts to undertake. These include estimating the extent of poverty among Latin America's indigenous population, and comparing the living conditions of the indigenous population with those of the non-indigenous population. The basic human capital differences between the two populations are also examined.

Data and methodology

When conducting research on ethnicity and socio-economic development, certain problems must be addressed at the outset. These include: defining the target population; deciding which research methodologies to apply; and overcoming the scarcity of data. The approach taken here is empirical analysis using microdata from household surveys conducted in four Latin American countries.

While many countries in the region have sizeable indigenous populations, few have questions designed to identify the ethno-linguistic characteristics of individuals in their household or labour-force surveys. Definitions of indigenous people differ from country to country due to the use of different survey instruments. Given the available data, three different variables identify indigenous respondents: language spoken; self-perception; and geographic concentration. In this analysis, language defines the indigenous population in Bolivia and Peru. In Bolivia, it is possible to distinguish between monolingual and bilingual (Spanish and indigenous language) individuals, while in Peru only monolingual indigenous or Spanish speakers can be isolated. The Guatemalan study uses the self-identification or self-perception method of defining the reference population. The geographic location or concentration of the indigenous population is generally used in combination with questions dealing with self-perception or language identity when the indigenous population is concentrated in specific territories. This is the method that has been used to include Mexico, a country with a large absolute number of indigenous people.

The poverty analysis includes profiles of the poor, with overall estimates of poverty rates for indigenous and non-indigenous populations. Poverty rates according to selected characteristics are presented in an attempt to better isolate the correlates of poverty. The 'headcount' index of poverty, that is the proportion of the population with an income below the poverty line, is estimated.

Definitions of poverty and poverty indicators are numerous, and substantial disagreement exists on which of them are more relevant. This study, however, in its focus on the indigenous dimension, settles on a standard methodology and attempts to avoid the methodological and theoretical issues associated with designing a poverty line. In an attempt to analyze the existence and correlates of absolute poverty, a poverty line—a measure that separates the poor from the non-poor—is used. Those whose income falls below the line are poor; those above are non-poor. Following convention, two poverty lines are used: an 'upper' and a 'lower' poverty line. These indicate the boundary between the poor and the very poor, respectively. The lower poverty line will be referred to here as the 'extreme poverty line'.

The country analyses in this study utilize an income-based definition of poverty, whereby individuals living on a per capita household income of less than a given standard are classified as poor. A uniform poverty line of US $60 per person per month in 1985 purchasing power parity (PPP) dollars is used. An extreme poverty line of US $30 per person per month in 1985 PPP dollars is also utilized.

While a profile of the poor is useful and informative, it is based on only a few categories of independent variables. For a more thorough investigation of the determinants of poverty, a multivariate model is used to standardize the many factors that simultaneously affect the probability of an individual being poor. A model is used in an attempt to capture the major determinants of poverty at the individual level. The model expresses the probability of being poor as a function of various characteristics such as education, employment, and being indigenous.

Empirical results

POVERTY

Poverty among Latin America's indigenous population is pervasive and severe (see Table 1). In Bolivia, while more than half of the total population is poor, over two-thirds of the bilingual indigenous population and almost three-quarters of the monolingual indigenous population is poor. The majority (66 %) of the population of Guatemala is poor, with 38 % of all households below the extreme poverty line. The indigenous population, however, is disproportionately poor: 87 % of all indigenous households are below the poverty line and 61 % are below the extreme poverty line.

TABLE 1: Poverty in Latin America (percent of population below poverty line)

	Indigenous	Non-indigenous
Bolivia	64.3	48.1
Guatemala	86.6	53.9
Mexico	80.6	17.9
Peru	79.0	49.7

Source: Psacharopoulos and Patrinos, 1994.

In Mexico, individuals in 'more indigenous' *municipios* suffer poorer socioeconomic condition than individuals in less indigenous *municipios*. A positive correlation exists between municipio indigenous concentration and the incidence of poverty. *Municipios* of increasing indigenous concentration experience higher percentages of poverty and extreme poverty. In *municipios* with a less than 10 % indigenous population, the poverty headcount index is 18 %; in *municipios* which are 10 to 40 % indigenous, 46 % of the population is poor; and in municipios which are more than 70 % indigenous, over 80 % of the population is poor.

Most of the indigenous population of Peru is poor — 79 % — and more than half is extremely poor. In fact, indigenous people are one-and-a-half times as likely to be poor than are non-indigenous people, and almost three times as likely to be extremely poor. Consequently, indigenous people account for 11 % of the sample population, yet they comprise 19 % of the poor and 27 % of the extremely poor Peruvians.

The results of a statistical analysis of the determinants of poverty in Mexico reveals that a 1 % increase in the *municipio's* indigenous population leads to an increase in the individual's probability of being poor by approximately one-half of a percentage point. This variable has considerable impact given a potential range of indigenous population concentration of zero to 100 %. Living in a 50 % indigenous *municipio* increases one's probability of being poor by a substantial 25 %, marking the greatest possible increase in the probability of being poor of any observed factor.

In a similar exercise for Bolivia, it was found that being indigenous increases the probability of being poor by 16 %. The probability of poverty increases by almost 45 % for household members whose head of household is unemployed. This suggests that employment is more important than being indigenous in reducing poverty. Among indigenous heads of household, participation in the labour force leads to a 40 % reduction in the incidence of poverty.

LIVING CONDITIONS

The living conditions of the indigenous population are generally abysmal, especially when compared to the non-indigenous population. In Guatemala, the majority of the population does not have access to such public services as water, sanitation and electricity. Less than one-third of all indigenous households have water piped to their homes for their exclusive use, compared to almost half of non-indigenous households. Approximately one-half of all indigenous households have no sanitary services, and three-quarters have no electricity.

In Bolivia, households headed by a non-indigenous person have more rooms per capita than do households headed by an indigenous person. And although the indigenous group has a much higher level of home ownership, this says little about the quality of housing, which is lower for the indigenous group. This is reflected in the lower rate of sewage connections in indigenous households and the lower prevalence of latrines. An important finding is the substantially higher prevalence of land ownership among indigenous people. This could indicate that indigenous people maintain ties to rural areas, allowing them to maintain already-established support networks.

In the less-indigenous areas of Mexico, material possessions such as televisions, refrigerators and automobiles are more plentiful than in the more indigenous areas. Services such as piped water, electricity and telephone service are also more common in less indigenous areas. In contrast, home ownership is more prevalent in more indigenous areas, but a closer examination reveals a clear disparity in the physical composition of homes between more and less indigenous *municipios*. Homes in less indigenous areas are built from higher quality materials: 71 % are constructed with concrete and brick, while in more indigenous areas only 29 % are concrete and brick. A larger percentage of homes in indigenous areas are built with wood: 21 %, as opposed to 6 % in less indigenous areas.

While indigenous people are more likely to own their homes in Peru, here, too, the physical composition of these homes is consistently inferior in comparison with those of Spanish-speakers. Of particular importance is the availability of public water and sanitation facilities. Only 46 % of indigenous homes have public-water facilities, while 31 % use wells and 15 % use the river as a source of water; only 21 % of indigenous homes have public waste disposal. An examination of rural/urban differences further highlights the indigenous population's deprivation. As indigenous households are less likely to have a public source of water in both rural and urban areas, indigenous people are much more likely to obtain water from wells; 16 % of urban indigenous households and 39 % of rural indigenous households have wells, whereas the corresponding proportions of Spanish-speaking households are only 2 and 10 %. The rural prevalence of indigenous people results in their greater exposure to the diseases associated with poor water quality. Almost half of all indigenous households rely on kerosene as a source of light; 88 % of the homes of Spanish speakers use electricity. Within urban areas, the use of kerosene is seven times greater in indigenous homes than in the homes of

Spanish speakers. The relatively large proportion of urban indigenous households without public water, public sewage disposal and electricity is evidence of a group of indigenous squatter settlements in the urban areas.

EDUCATION

There is a very strong correlation between schooling attainment and being indigenous, and between schooling attainment and the poverty category. In Bolivia, the schooling levels of indigenous people are approximately three years less, on average, than for non-indigenous individuals. The difference is even greater for indigenous females, suggesting that they are the most disadvantaged group in Bolivian society. In Guatemala, the majority of indigenous people have no formal education and of those who do, the majority have only primary education. On average, indigenous people have only 1.3 years of schooling and only 40 % are literate.

Access to formal education in Mexico has expanded in recent years, and improvements have been made in indigenous areas. Nevertheless, educational levels remain higher in areas with non-indigenous populations. Illiteracy continues to be an important problem for some states, especially those which are predominantly indigenous. The rate of illiteracy increases for both males and females as *municipio* indigenous percentages rise. The disparity is greatest in the female subsample, where the illiteracy rate is more than four times greater in the 'high' indigenous *municipio* category than in the 'low' indigenous *municipio* category. In addition, the gender disparity in the illiteracy rate increases as the *municipio* indigenous percentage increases. For the least indigenous *municipios,* the male/female difference is only 2 %; but for the 'high' indigenous *municipios,* the difference is 16 %, showing a pattern of increasing male/female educational inequities as *municipio* indigenous concentration increases. The higher the proportion of indigenous people in a *municipio,* the lower the average level of schooling of its population. Males, on average, have almost seven years of schooling in those *municipios* with less than 10 % indigenous population, whereas males in those *municipios* with 40 % or more indigenous population have only 3.5 years of schooling.

For the adult population of Peru, the difference between indigenous and non-indigenous people's educational attainment has narrowed in recent years. Even so, non-indigenous people have 20 % more education than do indigenous people. Not only is the indigenous population less educated and less literate than the Spanish-speaking population, but it also lags behind the non-indigenous population in terms of training. Differences in educational levels of indigenous and non-indigenous individuals are substantial. Only 40 % of indigenous heads-of-household have education in excess of primary school. In contrast, 41 % of Spanish-speaking heads-of-household have some secondary school education, and 22 % have some post-secondary education. Only 6 % of indigenous heads-of-household have some post-secondary education. Educational gaps between the indigenous and non-indigenous populations, as well as between genders, have tended to decrease over time.

The parents' skills and educational attainment are reflected in the schooling and other human capital characteristics of their children. In Guatemala, 9 % of non-indigenous children and 21 % of indigenous children are reported as being employed. The children of indigenous origin are born with many socio-economic disadvantages and are unable to keep up with their non-indigenous peers. Indigenous children are more likely to repeat grades at the primary level and are more likely to drop out of school altogether.

In Bolivia, non-indigenous children aged 6 to 18 years are still much more likely to be enrolled in school than indigenous children. Interestingly, the poorer children are actually more likely to be enrolled than the non-poor children. In terms of years of schooling attained among the in-school population, non-indigenous children receive more schooling than do indigenous children regardless of gender. Multivariate analysis shows that being indigenous has a strong effect on schooling attainment. In terms of school enrolment, the participation rate is slightly higher among males, with a greater percentage of non-indigenous youths attending school than indigenous youths.

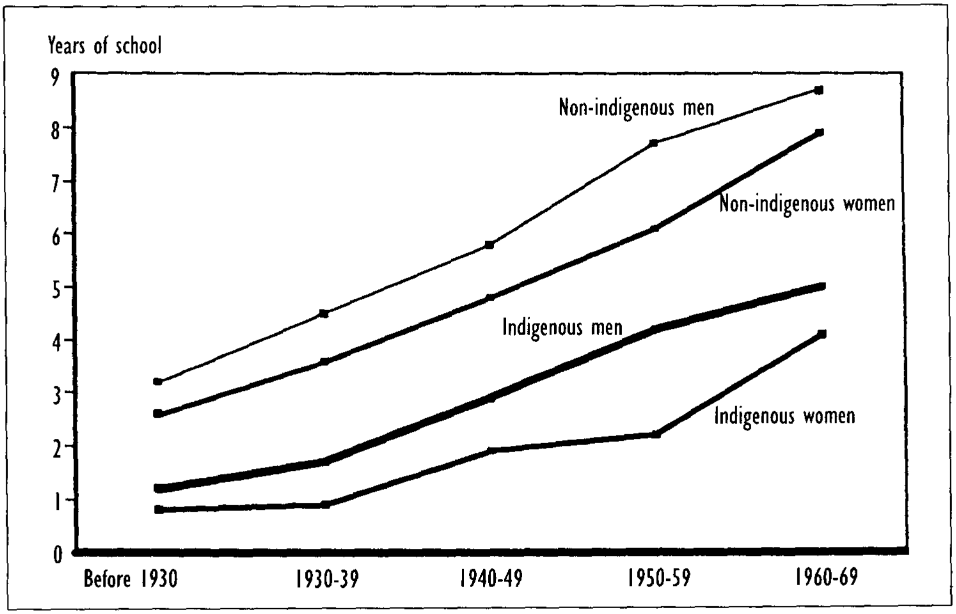
In Peru, 40 % of non-indigenous children are enrolled in school, as compared to 36 % of indigenous children. The effects of language and rural location are reflected in school attendance. Among the indigenous population, school attendance is greater among Aymara speakers than it is among Quechua speakers, and greater still among urban children. School attendance is also affected by child labour, both in the home and in the labour market; as hours worked by the child increase, school attendance decreases. Being indigenous is a major determinant of child work-force participation. Among the indigenous population, Quechua speakers are much more likely to work than are Aymara speakers. In addition, both parental employment and education affect the work decision of indigenous children. Children of less-educated parents, children of fathers who are employed as farmers, and children of mothers who are not in the labour force are more likely to work.

In Mexico, enrolment rates are higher in non-indigenous areas. The gap in enrolment rates between indigenous and non-indigenous areas widens with age, reaching a peak at 17 years, at which point the non-indigenous enrolment rate is approximately twice the indigenous rate. Child labour-force participation is greater in indigenous areas than in non-indigenous areas. This can be partially explained by the rural concentration of the indigenous population. Parental education plays an important role in average educational levels among children. The average increase in school attainment for a child with a mother with secondary or greater education, as opposed to a mother with no education, is 3.5 years in non-indigenous areas. Similar differences exist in indigenous areas. Where comparisons are available, the impact of parental education is greatest in less-indigenous *municipios*. The employment conditions of the head-of-household also have a clear impact on a child's average educational attainment. Heads-of-household who work in non-agricultural pursuits in either indigenous or non-indigenous areas have children with higher levels of educational attainment than otherwise employed heads-of-household. The contribution of the income of working children to total family income is substantial. As expected, the contribution of child labour to family income increases with age, while increasing educational attainment reduces the contribution. Child income plays a slightly greater role in total family income in indigenous areas than in non-indigenous areas.

Discussion

There is, fortunately, an unrealized potential. This is evident throughout Latin America and is highlighted here for the case of Mexico (Figure 1). The educational level of the population has been increasing rapidly over the last few decades. The average schooling level of indigenous males has increased continuously over time. For indigenous women, the post-1950s increase is particularly remarkable. The statistical results show that by equalizing human capital characteristics, much of the income differential between indigenous and non-indigenous people would disappear. These findings suggest that since policy-influenced variables, such as education and occupation, are largely responsible for income differences, the socio-economic condition of indigenous people in Latin America can be improved. This provides considerable hope for the future. The question that remains, however, is how to improve the productive capabilities of the indigenous population. One obvious solution is to raise their educational level.

FIGURE 1: Educational attainment by ethnicity and birth cohort in Mexico



Source: Psacharopoulos and Patrinos, 1994.

For education projects, knowledge about the indigenous population can aid in determining the location of new schools, targeting those with poor performance, and — when and if appropriate and in demand — providing bilingual education. The apparent strong influence of education in ameliorating poverty and increasing income, especially in indigenous areas, conveys a need to focus on improving access; this is an important development issue with significant and beneficial long-term socio-economic repercussions.

The involvement of indigenous people can aid in the improvement of the design and implementation of development projects. First, agreement on what must be done should be reached between the interested parties. It is necessary to decide on the goals of the intervention from the outset. Is it reform? And if so, what is meant by reform? In the case of indigenous people, is the goal assimilation, integration and the erasure of indigenous culture? Or is it the preservation of indigenous culture through policies designed with the participation of indigenous people? In the case of education, the lack of meaningful participation by indigenous people could result in the loss of their culture and language.

Institutional issues associated with the functioning of labour markets are also important considerations. To some extent, indigenous people receive lower earnings and have a higher incidence of poverty because they are locked into the secondary sector of the economy. This information can aid in the creation of appropriate employment generation schemes. While many poor and non-poor workers are located in the informal sector of the economy, it is especially important for the indigenous poor. This information points to an appropriate sector to be targeted in any poverty-reduction strategy.

The Western model of development views traditional cultures as poor, so that efforts are directed at improving their standard of living. This is based on the ideology that all cultures must achieve a certain level of material acquisition in order that they can be developed. There is the belief that tribal cultures are unable to satisfy the material needs of their people. Some argue that all people share a desire for what is defined as material wealth, prosperity and progress. Others, it is believed, have different cultures only because they have not yet been exposed to the superior technological alternatives offered by industrial civilization. The problem with this reasoning is that the materialistic values of the industrialized countries of the world are not culturally universal. Indigenous populations are different, and taking this into account means not imposing non-indigenous values. Any attempt to improve the conditions of indigenous populations would benefit from the consideration of 'traditional' customs and expertise.

FUTURE RESEARCH

There is a lack of empirical studies regarding the socio-economic conditions of Latin America's indigenous population. Important issues to be tackled include: defining the target population; solving the problem of scarce data; and designing appropriate research methodologies.

To identify the reference population in this study, it was necessary to make do with surveys that provide single indicators. However, what is needed are multiple indicators — as used in the United States and Canada censuses. A whole range of indicators are necessary, including language, self-identification or self-perception, geographic location or concentration, ancestry and, possibly, dress (as in the Guatemala 1993 census).

Therefore, what is needed is better data, so that in the future researchers can undertake more in-depth analyses and include a larger number of countries. In addition, longitudinal research could be conducted; that is, an attempt should be made to answer questions such as: 'What was the level of discrimination ten, twenty and thirty years ago?' 'What will it be five, ten or thirty years from now?' 'What were the effects of past policies and programmes?' 'What will be the effects of present policies and programmes?'

It may also be useful to study the experiences of developed countries with indigenous populations. Their treatment of the 'indigenous question' could prove useful, especially in terms of analyzing what these countries did successfully and what efforts were unsuccessful. The information at their disposal, as well as how they use it and collect it, could also be examined.

A future research project on indigenous people could combine the quantitative approach taken here with qualitative analysis, such as the participatory/observation research approach. The idea is to combine comprehensive empirical work with field work and micro-survey techniques. For example, if it is found that indigenous people in the cities of Bolivia are working as self-employed individuals and earning less than non-indigenous individuals with the same level of schooling, then in-depth interviews with these groups should be conducted to ascertain the reasons for the income discrepancy. Without this qualitative data, probable reasons for the discrepancy, including ethnicity, access to training and cultural values, are merely speculative. Such sophisticated differences are difficult to assess using only empirical analysis, generally based upon less-than-perfect data sets.

Many indigenous people living in urban areas maintain ties with the rural communities, to their mutual advantage. Resources are constantly being exchanged between town and country. This transfer of resources is important and not always adequately captured in household survey data. Such complex social networks can only be examined with a qualitative research approach. An examination of informal safety nets can be accommodated through a participatory research exercise.

The unpaid but productive activities of indigenous people living and working in rural communities are often misrepresented as unemployment or underemployment. Many peasants, however, are often involved in a variety of activities that provide income, although these are not easily observed, especially with aggregate household data. Apparently idle peasants are in most cases heavily involved in many activities which are not easily categorized. This type of information can only be obtained through direct observation. The information collected can be quantified and analyzed to aid in the design of rural development efforts with indigenous components.

There is much useful information regarding the manifestations of poverty that individuals do not usually disclose openly. This may include information about their health, sanitation practices, attitudes and behaviour regarding birth control, income or discrimination. A new approach, therefore, is necessary to supplement conventional sources. Conversational interviews can be used to ascertain not only the people's income and ability to pay, but also their values with regard to language, history, and culture. It may be most effective to involve the target populations in the design of surveys and projects, and to discuss the purpose of these initiatives with target groups.

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PEER ABUSE OR BULLYING AT SCHOOL: BASIC FACTS AND A SCHOOL-BASED INTERVENTION PROGRAMME

Dan Olweus

Bullying among schoolchildren is certainly a very old and well-known phenomenon. Though many are acquainted with the problem, it was not until fairly recently–in the early 1970s–that the phenomenon was made the object of more systematic research (Olweus, 1973; Olweus, 1978). For a number of years, these efforts were largely confined to Scandinavia. In the 1980s and early 1990s, however, bullying among schoolchildren also attracted attention in other countries such as Australia, Canada, Japan, the Netherlands, the United Kingdom and the United States of America (Olweus, 1993*a*; Farrington, 1993).

In my definition, *a student is being bullied or victimized when he or she is exposed, repeatedly and over time, to negative actions on the part of one or more other students.* Negative actions can be carried out by physical contact, by words, or in other ways, such as making faces or vulgar gestures, and intentional exclusion from a group. In order to use the term bullying, there should also be an *imbalance in strength (an asymmetric power relationship).* The student who is exposed to the negative actions has difficulty defending himself or herself.

Some data on prevalence

On the basis of our surveys of more than 150,000 Norwegian and Swedish students using my Bully/Victim Questionnaire, one can estimate that some 15 % of

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the students in elementary and secondary/junior high schools (grades 1 to 9, roughly corresponding to ages 7 through 16) in Scandinavia were involved in bully/victim problems with some regularity (autumn 1983) as either bullies or victims (Olweus, 1993a). Approximately 9 % were victims and 7 % bullied other students. Very likely, these figures represent underestimates of the number of students involved in these problems during an entire school year.

Bullying is thus a considerable problem in Scandinavian schools, a problem that affects a very large number of students. Recent data (in large measure collected with my Bully/Victim Questionnaire) from a number of other countries indicate that this problem certainly also exists outside Scandinavia and with similar or even higher prevalence rates (for references, see Farrington, 1993; Olweus, 1994).

There are many more boys than girls who bully other students, and boys are also somewhat more often victims of bullying. However, there occurs a good deal of bullying among girls as well, but girls typically use more subtle and indirect ways of harassment. A good deal of bullying is also carried out by boys toward girls and by older students toward younger ones.

Characteristics of typical victims and bullies

Briefly, the typical victims are more anxious and insecure than students in general. Further, they are often cautious, sensitive and quiet. Victims suffer from low self-esteem, they have a negative view of themselves and their situation. If they are boys, they are likely to be physically weaker than boys in general.

I have labelled this type of victim *the passive or submissive victim,* as opposed to the far less common provocative victim (Olweus, 1978; Olweus, 1993*a*). In summary, it seems that the behaviour and attitude of the passive/submissive victims signal to others that they are insecure and worthless individuals who will not retaliate if they are attacked or insulted. In a nutshell, the typical victims are characterized by an *anxious and submissive reaction pattern combined* (in the case of boys) *with physical weakness.* Follow-up data indicate that the former victims of bullying at school tended to be more depressed and had lower self-esteem at the age of 23 than their non-victimized peers (Olweus, 1993*b*). The results also clearly suggested that this was a consequence of the earlier, persistent victimization which thus had left its scars on their minds.

A distinctive characteristic of typical bullies is their aggression toward peers. This is, indeed, implied in the definition of a bully. But bullies tend to be aggressive toward adults as well, both teachers and parents. They are often characterized by impulsivity and a strong need to dominate others. They have little empathy with victims of bullying. If they are boys, they are likely to be physically stronger than boys in general, and the victims in particular.

The common assumption that bullies are basically insecure individuals under a tough surface has been tested in several of my own studies and with various methods including projective techniques and stress hormones, but received no support. The empirical results pointed in fact in the opposite direction: the bullies had usually little anxiety and insecurity, or were roughly average in such dimensions.

In summary, typical bullies can be described as having an *aggressive reaction pattern combined* (in the case of boys) *with physical strength.*

Bullying can also be viewed as a *component of a more general antisocial and rule-breaking (conduct-disordered) behaviour pattern.* In my follow-up studies, we have found strong support for this view. Approximately 35 to 40 % of boys who were characterized as bullies in grades 6 through 9 (ages 12 to 15) had been convicted of at least three officially registered crimes by the age of 24. In contrast, this was true of only 10 % of the 'control' boys. Thus, as young adults, the former school bullies had a fourfold increase in relatively serious, recidivist criminality.

A question of fundamental democratic rights

The victims of bullying form a large group of students who are, to a great extent, neglected by the school. For a long time, I have argued that *it is a fundamental democratic right for a child to feel safe in school and to be spared the oppression and repeated, intentional humiliation implied in bullying.* No student should be afraid of going to school for fear of being harassed or degraded, and no parent should need to worry about such things happening to his or her child.

Already in 1981, I proposed the introduction of a *legal paragraph against bullying* at school. At that time, there was little political support for the idea. In 1994, however, this suggestion was followed up in Sweden with a new school law paragraph including formulations that are very similar to those expressed above. In addition, the law and associated regulations place responsibility for the realization of this goal, including development of an intervention programme against bullying for the individual school, with the principal. At present, the ratification of a similar law is being discussed in Norway, and there now seems to be considerable political support for this proposal.

Effects of a school-based intervention programme

Against this background, it is now appropriate to describe briefly the effects of the intervention programme that I participated in developing, and evaluated in connection with a nationwide campaign against bully/victim problems in Norwegian schools.

Evaluation of the effects of the intervention programme was based on data from approximately 2,500 students originally belonging to 112 grade 4 to 7 classes in 42 primary and secondary/junior high schools in Bergen, Norway. The subjects of the study were followed over a period of 2.5 years.

The main findings of the analyses can be summarized as follows (Olweus, 1991; Olweus, 1993*a*).

— There were marked reductions–by 50 % or more–in bully/victim problems over the periods studied, with eight and twenty months of intervention, res-

pectively. By and large, the results applied to both boys and girls and to students from all grades studied.
- There were also clear reductions in general anti-social behaviour such as vandalism, fighting, pilfering, drunkenness and truancy.
- In addition, we could register marked improvement as regards various aspects of the 'social climate' of the classroom: improved order and discipline, more positive social relationships, and a more positive attitude to schoolwork and the school. At the same time, there was an increase in student satisfaction with school life.

Brief comments

The reported effects of the intervention programme must be considered quite positive, in particular since many previous attempts to reduce aggressive and anti-social behaviour systematically in pre-adolescents and adolescents have been relatively unsuccessful. The importance of the results is further accentuated by the fact that there has occurred a highly disturbing increase in the prevalence of violence and other anti-social behaviour in most industrialized societies in recent decades. In the Scandinavian countries, for instance, various forms of registered criminality, including criminal violence, have typically increased by 400 to 600 % since the 1950s or 1960s. Similar changes have occurred in most Western, industrialized societies.

Basic principles

The intervention programme is built on a limited set of key principles derived chiefly from research on the development and modification of the implicated problem behaviours, in particular aggressive behaviour. It is thus important to try to create a school (and, ideally, also a home) environment characterized by warmth, positive interest and involvement from adults on the one hand and firm limits to unacceptable behaviour on the other. Third, in cases of violations of limits and rules, non-hostile, non-physical sanctions should be consistently applied. Implied in the latter two principles is also a certain degree of monitoring and surveillance of the students' activities in and out of school. Finally, adults both at school and at home are supposed to act as authorities in at least some respects.

These principles have been 'translated' into a number of specific measures to be used at the school, class, and individual levels (see Table 1 below).[1]

With regard to implementation and execution, the programme is mainly based on utilization of the existing social environment: teachers and other school personnel, students and parents. Non-mental health professionals thus play a major role in the desired 'restructuring of the social environment'. 'Experts' such as school psychologists, counsellors and social workers serve important functions as planners and co-ordinators, in counselling teachers and parents (groups), and in handling more serious cases.

TABLE 1: Overview of core programme

GENERAL PREREQUISITES	
**	Awareness and involvement on the part of adults
MEASURES AT THE SCHOOL LEVEL	
**	Questionnaire survey
**	School conference day
**	Better supervision during recess and lunch time
*	Formation of co-ordinating group
*	Staff/parents meetings (PTA meeting)
MEASURES AT THE CLASS LEVEL	
**	Class rules against bullying
**	Class meetings
MEASURES AT THE INDIVIDUAL LEVEL	
**	Serious talks with bullies and victims
**	Serious talks with parents of involved students
*	Teacher and parent use of imagination

NOTES:
** Core component
* Highly desirable component

Possible reasons for the effectiveness of this non-traditional intervention approach have been discussed in some detail (Olweus, 1992). They include a change of the 'opportunity' and 'reward structures' for bullying behaviour. It is also emphasized that bully/victim problems can be seen as an excellent *entry point* for dealing with a variety of problems that plague today's schools.

This anti-bullying programme is now in use or in the process of being implemented in a considerable number of schools in Europe and North America. Though so far few research-based attempts have been made to evaluate the effects of the programme beyond the study in Bergen, unsystematic information and reports indicate that the general approach is well received by adults in the school environment and that the programme (with or without cultural adaptations or additions of culture-specific components) works well under varying cultural conditions including ethnic diversity. There has, however, recently been made one additional large-scale evaluation of the basic approach, containing most of the core elements of the programme and with a research design similar to that of our study (Smith & Sharp, 1994). In this project too, comprising twenty-three schools (with a good deal of ethnic diversity) in Sheffield, United Kingdom, the results were quite encouraging (though fewer behavioural aspects were studied). It can be argued that the robustness and possible adaptability of the programme is not really surprising, since the existing evidence seems to indicate that the factors and principles affecting the development and modification of aggressive anti-social behaviour are fairly similar across various cultural contexts, at least within the Western, industrialized part of the world.

Conclusion

The basic message of our findings is quite clear: *it is definitely possible to reduce bully/victim problems dramatically in school and related problem behaviours through a suitable intervention programme.* This programme can be implemented with relatively simple means and without major costs; it is, above all, a question of changing attitudes, behaviour and routines in school life. Introduction of the programme is very likely to have a number of other positive effects as well.

Note

1. The 'package' related to the intervention programme consists of the Bully/Victim Questionnaire (which may be ordered from the author; to be published by Blackwell, United Kingdom, in late 1995), a 20-minute video cassette showing scenes from the everyday lives of two bullied children (with English subtitles; this video can be ordered from the author), and a copy of the book *Bullying at school: what we know and what we can do,* Oxford, U.K. (Cambridge, U.S.A.), Blackwell Publishers, which describes in detail the programme and its implementation. Author's address: Prof. D. Olweus, Department of Psychosocial Science, University of Bergen, Oysteinsgate 3, N-5007 Bergen, Norway.

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