Categorizing National Computer-Related Educational Policy: A Model and Its Applications

Betty A. Collis

Department of Education
University of Twente
Postbus 217
7500 AE Enschede
The Netherlands

João B. Oliveira

Economic Development Institute
The World Bank
1818 H Street N.W.
Washington, DC, USA

Abstract

Countries throughout the world now have experience with national policy relating to computer use in education. However it remains difficult to synthesize this experience. Some method of conceptualization about pertinent features of national policies could help educational decision makers make more informed predictions about the likely consequences of similar decisions in their own countries. In this context a model is presented which attempts to support such a synthesis of international experience. The model describes four general categories of national policy with respect to computer use in education. The model is then used as a framework for discussing the likely implications of policy within each of the different categories relative to various aspects of computer use such as its objectives, hardware and software considerations, teacher training and support, research, and national capacity building.

1. Introduction

Some aspects of computer use in education have been experienced by virtually every country in the world.¹ In some countries this experience has a longer history and a broader scope than in others. While no country feels it has reached a 'final' position relative to policy on applications

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The authors are solely responsible for the opinions discussed in the present paper.

¹Comments throughout this paper about national policies are based on information available to the authors, sometimes in the form of official policy statements, other times through sources as informal as personal communication. Certain key documents used as references are cited in the Reference List at the end of the paper.

of computers in education, enough experience has been accumulated to allow some generalizations about patterns of national policy to emerge. These generalizations can be useful if, through them, countries who are still in early stages of policy formation can make more informed predictions of possible short- and long-term implications of different national policy orientations with respect to the use of computer-related technology in education. This utility can be particularly valuable to policy makers in less developed countries, who, because of severely limited resources and magnified problems, cannot afford to undertake costly explorations, or make costly mistakes with respect to computer-related policy and initiatives. However, despite the value of such generalizations about computer-related policy in education, they do not often seem to be made. Partly this might be because of the difficulty of accumulating timely information from a rapidly emerging area. However, it may also be a reflection of the lack of a manageable scheme to reduce the many pieces of individual experience regarding computer-use policy into a few dominant patterns.

In this context, therefore, we will develop a general model for national policy relating to computer use in education. One model describes four different categories of national policy based on our own synthesis of policy components. Referring to these models, we will predict some most-likely implications associated with each model with respect to critical dimensions of national computer policy for education; dimensions such as goals for computer usage, hardware selection, software procurement, teaching, training and support, research, and capacity building. We will conclude with some reflections about major issues in national policy relative to computers in education. We restrict our discussion to publicly financed basic and general secondary education, as opposed to vocational education and training or to postsecondary education.

2. Examples of computer-related educational policy

Before we present our general model for computer-related educational policy, it is useful to summarize some of the most significant focal areas for such national policy. We will therefore make some brief comments about the major focal areas. The first of these relates to the overall orientation that a country has with respect to policy about computer use.

2.1 *Comprehensive national policies*

Every country has some position regarding national policy for computer applications in education, even if the policy is one of having no formal policy. In some countries the position relative to policy may involve extensive national programs providing central directives for a number of aspects of computer use. France, for example, in 1985 announced a nationwide plan to 'introduce all pupils at every level of education to information technology'. During 1985-1986, to implement this plan centrally chosen computer systems were placed in 33,000 schools, nearly a quarter of all teachers were trained in a 50-hour course, and over 240 million francs was spent on buying software. The Netherlands has had large-scale national policy initiatives for computers in education since at least 1984, involving integrated initiatives for software development, hardware selection, teacher training, and research. In Western Australia the government provides computers in all government schools ('to ensure an equitable distribution') gives support for training and software, and is committed to the integrated use of new technologies for distance education and networking. In Norway three levels of teacher training are used nationwide, an extensive software development activity is in place, and innovative projects involving computer technology are supported at a 'limited number' of schools who are given a 'large part of the resources' rather than the resources being distributed evenly but more sparsely throughout the country. The Scottish Council for Educational Technology has an extensive range of national projects involving 'educational microelectronics', coordinated centrally by a national body.

In contrast to these well established programs, other countries are developing national policies. For example, Egypt and Turkey recently announced plans to massively introduce computers in schools. In Turkey the Prime Minister promised to buy one million computers for schools, and authorities are considering the creation of one or two central units to produce educational software. Costa Rica is also launching a sizeable computer education program.

2.2 *National Policies for Informatics Courses*

Many other countries have national policies regarding some aspect or aspects of computer use in education but not covering the range of perspectives as were mentioned in the examples from France, The Netherlands, Western Australia, Norway, and Scotland. A popular focus for national policy is the development of some sort of compulsory computer-related experience for students.

Sometimes this experience is called 'computer literacy', or 'informatics', or 'information technologies' (IT). Typically the computer-related experience is operationalized by a required course for students of a certain age, almost always at the secondary level. Exceptions have been in Bulgaria and the United Kingdom, where programs for basic education have received considerable attention. National syllabi for compulsory courses in some aspect of information technology at the secondary school level have been organized in Sweden, Belgium, and Denmark, for example, among many other countries. The Federal Republic of Germany has established a 'framework for basic training in IT' for all pupils in stage I of secondary education but has left implementation decisions to the Länder. Mexico and India have plans for large scale computer literacy programs, and in the USSR well established pilot programs in computer science are being extended to all secondary students, with the objective to include information on computer science as part of general education.

2.3 National software development projects

National educational software development projects have already been mentioned as part of the national integrated initiatives in The Netherlands, Scotland, and Norway. Other countries, such as the UK, have also invested heavily in national software development projects. The Province of Ontario (in Canada), Sweden, and Israel have had major projects for a number of years. In Mexico a national initiative has resulted in the development and field testing of over 200 programs. In Brazil a government-supported consortium of five universities has been developing software and experimenting with its use in public schools since the mid-eighties.

2.4 National plans for hardware acquisition

Centralized support of educational hardware acquisition has been a major focus of national policy in many countries. The Netherlands, France, the UK, the Province of Ontario, and Sweden have central policies about hardware. Sometimes these policies have related to the actual specification of components for specially developed 'educational' computers. Policy issues may center on decisions regarding support of the domestic hardware industry in a country as opposed to internationally based vendors. Mexico, Hungary, and Ireland, among others, have national strategies about hardware acquisition and support.

2.5 National policy to support local initiative

Each of these examples has illustrated some centralized, directive national policy relating to computers in education. Portugal is an example of a country which is proceeding somewhat differently, in that it, too, has a national policy but one which has as an aim 'achieving a maximum of innovation and entrepreneurship' at the local level. Five different 'national nodes' each serve as a focal point of a collection of teacher training institutes, universities, and schools. National policy supports teacher training and projects chosen at the local level. The overall project provides for exchange of experience and expertise between the nodes, but the emphasis is on the local evolution of 'common solutions' rather on 'hierarchically established' central policy. Norway has a similar orientation. Many other countries support various individual local projects, but few attempt to nurture and promote synthesis among a broad range of projects.

2.6 'Undeveloped' national policies

In contrast to these examples, there are many other countries where little or no central support, with respect to policy or resources, is provided for computers in education. Sometimes this is a direct reflection of a decentralized structure for educational decision making within a country. The United States and Canada are major examples of such countries. Each has a high level of computer education activities, but leaves policy and support to the discretion of the state or provincial levels. Argentina and Columbia are examples of countries where there is a very low level of computer education, and when activities do occur they are primarily led by the initiative of individual researchers or private schools. Consequently, a great variety of uncoordinated activity takes place in those jurisdictions, making differences within those units as substantial as exist between entire countries elsewhere. The same is true of other developing countries in Asia and Latin America and the Middle Eastern countries, where private schools have been using computers in a number of different, generally uncoordinated ways.

Many less developed countries have as yet no formalized policy because of severely constrained educational budgets. In Argentina, for example, in spite of the lack of formal governmental support, a great deal of activity goes on in universities and specialized research centers. Particular emphasis is given to the use of Logo. Colombia follows a similar pattern, even though there is no particular predominance of Logo or other specific application. In some countries resources only allow a very limited use of

computers in education. For example, in Nepal such use of computers is restricted to engineering schools.

However, many countries are working on developing a policy, in the hope that computer application can be a cost-effective way to address at least some of their educational problems. Also, in the absence of both policy and resources, many of the less developed countries look keenly for nongovernmental support of local projects. In Kenya, for example, a pilot program to introduce computers into schools (the Computers in Education Project sponsored by the Aga Khan Education Service) was praised by the government for 'not having cost Kenya a single cent.'

2.7 Looking for patterns in the examples

These are only a few examples of international activity. How can we identify patterns in this multiplicity of examples? How can such patterns be used by educational decision makers to assist in the more systematic consideration of policy options? We suggest the following approach.

3. A model for national computer-related educational policy

After consolidating our observations with regard to computer-related national educational policy, we propose the following simple model (Figure 1):

Type A: Centralized, integrated	Type B: Centralized on specific projects	Type C: Central support of local projects	Type D: Limited or no central involvement
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Figure 1: Categories of national policy with reference to computers in education.

We have derived these categories using a logical analysis of our observations rather than through the process of applying a more traditional methodology. We propose that each category represents an abstract type with generalizable characteristics. These types may not serve as direct labels for specific countries, as, for example, many countries have different aspects of computer use representing more than one of the types. The types represent overall policy orientations.

The distinction between Type A and Type B is of both quantity and integration. Type A countries have central policies about a number of aspects of computer use in education, and attempt to integrate these policies together into a larger policy framework and infrastructure. Type B countries may have a similar number of centralized policies or priorities on one or more areas such as hardware, software or research, but do not attempt to interrelate them under a common policy directive in the way a Type A country does. More frequently, Type B countries will also differ from Type A countries in the number of initiatives under central direction. Together Types A and B can be called 'directive' policy types.

In contrast, Types C and D may be called 'emergent' policy types. In Type C a light, central infrastructure is required to provide leadership, motivation, guidelines, and to support and integrate differentiated initiatives arising from the schools. In Type D this type of infrastructure may be nonexistent, or, if existent, only marginally staffed and funded. Computer-related initiatives that occur must be independently organized and funded, even though some funds may come from governmental agencies.

We can now use these categories to predict likely outcomes relative to various aspects of computer use in education.

4. Using the model to predict outcomes of computer-related policy

We will discuss predictions from the perspectives, including national objectives for computer use, hardware, software, teacher training and support, research, and capacity building. In each case, we suggest economic and educational implications. Again we emphasize that our predictions are based on an aggregate of our observations of experiences to date at the national level.

4.1 Objectives for computer use

4.1.1 Comments on national-level objectives.

There are many different motivations for using computers in education.² At a high level these motivations can be distinguished in terms of their orientation—to introduce new vocationally-oriented skills and understandings or to improve the quality of instruction in existing subject areas. Parenthetically, a major characteristic of national policy with respect to objectives for computer use in education is, in our opinion, vagueness. Many times 'objectives' are no

² See the papers by Carnoy and Loop; Collis (1988a); Lallez; and Oliveira cited in the Reference List for more discussion of these motivations.

more than hopeful generalities—‘to better prepare our students for the future,’ or ‘To improve the quality of education.’ However, without objectives there is no effective way to measure progress or to bring cohesion to decisions about various lower-level aspects of computer use in education. Thus the degree to which a policy type can facilitate the setting and dissemination of operational objectives for computer use in education is an important consideration. A useful way to understand the impact of policies is to look into how countries establish curriculum priorities for computer courses, how they regulate what can be done by schools, and how they provide financial support and incentives for programs and projects.

4.1.2 Objectives relative to model type.

In order to have integrated national activities, Type A policies include some level of goal statement even if the statement is more implicit than explicit. In most cases, however, objectives will be articulated. A few countries have attempted to design and implement articulate computer education programs to reach a substantial number, if not the totality, of secondary schools and in some cases the primary schools as well. In addition, the policies often encompass other aspects of computer utilization, including hardware, software, teacher training, research, and support for utilization in schools.

In contrast, Type B objectives are often specifically focused on the development of hardware or software capabilities. In one approach it does not matter what schools do, as long as they use the hardware configurations decided by the central Ministry. In another approach the major objectives may be to develop national capabilities to produce educational software in general, to develop software for specific disciplines, or to utilize existing software at specific school levels. Different countries attach different priorities to the level and type of software to be produced. In some countries software development may be linked to the implementation of pilot projects in schools; in this case, teacher training components may be included.

An alternative strategy is the pilot-project approach, which may be seen as a scaled-down version of Type A policies. Given the more limited scope of these interventions, less emphasis may be given to any of their specific components, such as hardware procurement, software development, teacher training or research and evaluation, depending on the basic motivation underlying the institution sponsoring the program. The goals in a Type

B country may extend no further than the aims of the centrally-funded pilot project itself. This can be seen in countries where decisions about hardware specifications are made without much reference to specific objectives for student activities relative to computer use. In countries where this happens, hardware is often chosen on the basis of the range of its technical potential rather than on a statement of how students of a certain age may best use it.

The major goal of Type C policies is to 'probe' and experiment with the use of computers in education. In this case, policies may define broad priority areas or types of project that might qualify for government support. Often emphasis is given to small-scale software development and implementation of locally based exploratory interventions, more rarely to research and evaluation, and hardware considerations. The goals in Type C will remain at a general level in order to foster variety and local autonomy.

Type D policies can be alternatively described as markets or anarchies. The reason for a country to adopt Type D models may vary: a general preference for a market-like approach; a decentralized educational system; a dynamic private sector in computing; lack of central funds; or simply, lack of concern or priorities for computer education. By definition, Type D countries supply no national policy, unless perhaps at an ineffectually vague level.

4.1.3 Advantages of well defined national objectives.

The advantages of having a coherent national set of objectives for computer use in schools depend both on the structure of the educational system and the quality of the proposed program. National objectives can streamline decision making and the time needed to make decisions. Materials for both student use and teacher training can be produced to reflect economies of scale in a way not possible if shared objectives and policy are not present. Other particular economic and educational advantages relative to centralized policy for hardware, software, teacher training, research, and other aspects of educational computing use will be detailed in the following sections.

4.1.4 Limitations of well defined national objectives.

However, at least three major limitations should be considered. First, educational computing is still an emerging field. Despite nearly ten years' worth of school

experience in many countries, there is still little established knowledge base about effective uses of computers in schools. Partly this is because the field itself is continually evolving in terms of hardware and software possibilities. Also it is because effective computer use in education depends on so many interacting factors, interrelating with each other in processes which are as yet little understood.³ Thus national policy has the distinct limitation of quickly becoming obsolete. The difficulties of changing large-scale policy and the structure built around it are obvious. The presence of requirements relating to BASIC programming for students, and in some places also for teachers, are clear examples of policy reflecting the current wisdom of the time it was formed but now inappropriate. Uniform national policies may thwart innovation and discovery, much of which still needs to take place in this field.

The second limitation is related to this last point. There is consistent evidence in education that innovations are best nurtured and accepted when individuals have a sense of ownership and personal investment in them.⁴ Top-down policies in the highly innovative area of computers in education may ultimately fail to take root at the local implementation level. The particular contribution of the enthusiastic individual as a catalyst to computer use in education is well known. Type A and B policies could thwart this sort of natural development, unless policies are explicitly formulated to foster local initiatives, as in the case of Type C.

A third limitation refers to the cost of developing such policy, both in terms of time and energy. For some countries this sort of concerted action is needed in so many different areas that resources cannot be logically prioritized to focus on computers in education ahead of many other pressing areas for policy development.

4.1.5 Application of the model.

Type A and B policies could only work satisfactorily in countries with reasonably centralized school systems where there are adequate resources to extend the project to a reasonable number of students. Type D approaches could work better in countries with a strong market tradition and sufficient resources to allow competition and redundancy in the process of producing satisfactory outcomes. Type C would only meet its objectives to the extent that research

³ See Collis (1988b); Fullan, Miles, and Anderson; and Pea and Sheingold for more discussion of the complexities of this interaction.

⁴ See Rogers for fundamental work on the diffusion of innovations.

and evaluation mechanisms are in place to ensure that something is learned and then transferred from specific interventions to the larger system. Type C countries could make some progress in terms of articulating general objectives for computer use in schools (for example, suggesting an emphasis on computer use for curriculum enrichment, or for compensatory education in areas of educational disadvantage). This is consistent with an analysis done of 21 educational-change programs supported by a total of 42 World Bank projects⁵ where the goals of large-scale projects often clashed with the realities of school level implementation. The conclusion of this analysis is pertinent:

The most effective approach to the design and implementation of large-scale change programs appears to be a 'think big and start small' strategy . . . (where) a firm national commitment to change was combined with the acceptance of a substantial degree of diversity at the school level.⁶

4.2 *Hardware considerations*

Hardware procurement is a sensitive and time-consuming issue with regard to computers in education. Logically, educational priority setting should precede hardware acquisition. In this way, hardware can be purchased that best fits the educational needs of target groups of users. Having a large quantity of small, inexpensive machines, for example, may be more appropriate than having state-of-the-art machines for some purposes, such as young children using computers regularly for simple word processing in the context of their writing development.

4.2.1 Hardware standardization.

Hardware standardization can have different forms. One such form is to manufacture computers specifically designed for the education market or designed for other national purposes. Another is to specify guidelines for acceptable computers, and a third is to support one or more commercially available computers. Standardization is certainly a major decision to be faced by Type A and Type B countries, but is less of a problem in Type C, given the small scale and the low level of interaction between the various projects. Even though it is not an issue for Type D

⁵ See Verspoor. The report relates to large scale projects in less developed countries but it is likely that many of its findings are applicable to other settings.

⁶ Verspoor, p. 81.

countries, the lack of standardization creates obvious consequences for the supply of software.

4.2.2 Advantages of hardware standardization at the national level.

Hardware standardization within Type A and B countries can offer financial advantages that relate to economy of scale. Countries with such policies can also influence hardware vendors for inclusion of specific adaptations on hardware to better reflect educational purposes. Standardized hardware environments will offer more incentive to commercial software developers. Distribution and maintenance procedures can also be improved through economies of scale. Teacher training can become more efficiently delivered, as it can be structured around the specific characteristics of a given hardware configuration. The considerable amount of time which is spent on repetitive decision making about hardware choices from one local area to another can be put to more valuable educational use. Standardization is particularly important in countries where computers are associated with the use of curriculum-specific software, as opposed to general-purpose software. This is because the market for such software is already by definition small and will offer even less commercial incentive if it is splintered further among different hardware systems. Standardization of hardware is also very important if countries wish to maximize diffusion of software produced by teachers.

4.2.3 Disadvantages of hardware standardization.

However, centralized decisions about hardware also have their disadvantages. The most obvious one is the quick obsolescence of the hardware, a phenomenon now seen in many of the countries where national hardware policies were established more than four years ago. A second problem is that, even at a given point in time, experts do not agree on which specifications are most appropriate, if standardization is to be affected.⁷ Other problems may relate to political issues, such as a government giving a major contract to a non-national vendor.

The experience of countries which have standardized

⁷ This can be seen now in The Netherlands surrounding the specifications for a computer to qualify for government support at the basic education level. The issue became so strongly contested that it assumed political dimensions and was debated in Parliament.

hardware strongly suggests the need for flexibility within the standardization. The Province of Ontario in Canada, for example, which for many years subsidized the production of a high-power networked system for schools, is now offering schools the option of government support for the purchase of less-powerful machines, as long as these machines share some aspects of compatibility with the heavy-duty machines already in the system. It seems possible that the impact of scale which a national contract can bring can justify the country being aggressive in asking for some variety of price and scope of product from a vendor while still maintaining some degree of compatibility.

4.3 Software acquisition, evaluation, and distribution

As noted previously, the absence of global policy about computer use in schools and particularly about hardware is often cited as an inhibition to the development of commercial software production capability in a country. Software acquisition is a particularly sensitive issue, because of the problems involved both with developing one's own software and in adapting software produced in one country to the circumstances of a different country.⁸ Even when software is available within a country, major difficulties surround its dissemination. For example, although over 10,000 commercial educational software packages have been produced and are currently available in the United States, many teachers have no way of having evaluative contact with these programs except to send away for them for purchase.

Software policies are also constrained by previous decisions regarding objectives and hardware. The latter limit the size (capacity) and types (systems) of software that can be run on a given machine. The closer the relationship between computer use and specific curricula, the greater the tendency to favor central or controlled development. In many respects software development parallels the logic of textbook production.

4.3.1 Software policies relative to model types.

Type A countries have the best chance of organizing

⁸ See the paper from the Laboratory of Human Cognition, and also those of Murray-Lasso and Wombi. Wombi notes, for example, the difficulties involved in implanting foreign products into the different 'ecocultural frameworks' of less developed countries and suggests that this can lead to an alienation relating to more than communicative language. He cites a 'more profound silence that is political, technical, and ideological.' (p. 24)

centralized development, evaluation, and dissemination activities relative to software. They also have the best chance of integrating software into teacher training experiences that the teachers are subsequently likely to transfer into their own classrooms. Software can also be produced nationally in Type B systems; however, the problem of how to get it into the schools and used is much more difficult without integrated policies. National software development projects can operate at a professional standard within both Type A and B, something which is very difficult to realize when software is produced only at and for the local unit. Type C and D systems face major limitations with respect to software, a fact which is frequently acknowledged.

Centralized education systems adopting Type A policies will tend to develop and evaluate their own software in one or more national centers. Some countries, however, also explicitly encourage the development of software by individual teachers, as was the case in France. As one moves toward Type B and C policies, these issues become much more diffuse. Unless there is an explicit emphasis on one or a few disciplines, software will usually consist of a mixture of local development with adaptation and procurement from the existing software market. In Type C and D countries, particularly without hardware standardization, locally-produced software will seldom be evaluated or shared.

4.3.2 Software-related problems relative to model type.

Software-related problems are only reduced but not eliminated within even the most sophisticated of Type A and B software development projects. The quantity of software necessary to respond to national educational needs and desires is far beyond the capabilities of even the most productive national projects. Based on the experiences of countries with extensive national software development projects, we know that such projects are very expensive and require many years' investment before even a limited amount of software is available. The commercial marketplace must be stimulated to contribute to this national software base, but this will not happen to any appreciable degree, especially in the weaker markets of the less developed countries, until a clearer and more focused demand is present. This in turn rests on strong national policies and on hardware standardization.

4.3.3 Alternative approaches to software policy.

Regardless of policy Type, one response of several countries to these difficulties related to software development and procurement has been to focus more on the use of existing generic applications software packages, such as word and data processing, spreadsheets, and data base management programs. These sorts of packages are available already in most countries and frequently have been translated into the language of the country. In addition, these packages have substantial educational value when used creatively as educational tools.⁹ An alternative compromise suited to Type B and C countries is to develop only a specialized area of educational software (for example, software to accompany a certain range of the science curriculum in the country) and build teacher training and dissemination around this limited range, using generic applications software for the remainder of computer experiences. Obviously this approach also has limitations, particularly in that it constrains growth and application in many subject areas. However, it is a possible response to the expensive and difficult problem of acquiring and distributing appropriate educational software, especially given limited resources.

In addition, software policy may have different goals and require different incentives. Type B and C countries may be more interested in developing a national software development capacity per se. In that case, production will be concentrated at one or more centers. However, if products—rather than capacity building—are the major concern, then a number of policy options might be considered, such as producing software through centralized units, creating incentives for individual authoring or simply by acquiring products in the market.

4.4 *Teacher training and support*

4.4.1 General orientations for teacher training and support.

Teacher training is frequently cited as a major and necessary component of effective computer use in education. Many countries acknowledge this and, as we have noted, quite a few have developed national strategies for teacher training. There are critical differences between policy which sets up a course for all teachers and policy that will support the individual needs of teachers with varying degrees of computer experience and teaching in different subject areas. The latter is desirable in theory but

⁹ See Collis, 1988a; and Lockheed and Mandinach, 1986.

considerably more expensive and complex to mount in practice. A Type C country has the flexibility to tailor teacher training to some extent, as in the case of Portugal, where teacher training has been delivered in different ways in response to the requests of the organizational nodes.

4.4.2 Advantages and limitations of a decentralized approach.

The most typical situation world-wide, however, is that teacher training is left to individual units, and these in turn show many different patterns. Sometimes the training occurs through universities, or other postsecondary institutions, other times through the local educational unit itself, sometimes through private commercial enterprises. The result of such heterogeneity is predictable—heterogeneity in the experience and training of teachers. Also economies of scale with respect to the development of teacher-support materials are not possible. However, locally developed programs have some critical advantages—for example, they can be responsive to the particular interests and characteristics of the teachers involved, a potentially serious deficiency in national-scale programs. As part of this responsiveness, they can offer on-the-job support, a factor often cited by teachers as valuable to them as they try to implement what they have learned in training experiences. In addition, the fact that they are often developed and taught by local staff helps to support professional growth and leadership at the local level.

4.4.3 Application of the model to teacher-related considerations.

Given some equitable access to resources for training, it could seem from experience so far that locally developed and supported teacher training has important advantages. However, without this 'given', which in turn requires careful planning within the context of Type A, B, or C systems, teacher training is likely to continue to be the generally frustrating area that it is today.

4.5 Research and other considerations

4.5.1 Research.

A major limitation in Type B, C, and D systems is a mechanism for system-wide research and evaluation. Even when local research projects are mounted, little attempt is

made to synthesize their findings beyond the idiosyncrasies of the local area. Calling for more and better research into the effectiveness of computer use in schools is a standard concluding paragraph to reports about computers in education. Type A systems have the infrastructure and authority to do comparative and integrative research on a nation-wide basis, although not many have taken advantage of the opportunity. The importance of it, however, should not be underestimated. Countries choosing to operate at predominantly a Type B, C, or D level should, we believe, still try to support some research on a national basis about computer effectiveness and the problems that appear to constrain this effectiveness. National centers or projects for research and evaluation may be a valuable investment and perhaps could be developed even in Type D systems.

4.5.2 Other considerations.

Other national policy focuses can relate to equity of access to computer-related resources, support of telecommunications, and dissemination of information.

Equity issues are frequently cited.¹⁰ Without central intervention it appears that inequitable access to computer resources within countries are inevitable. Unless the policy of a country is to implicitly or explicitly let its more advantaged schools and students become still more advantaged relative to others, it appears that policy-related funds and resources must be available to stimulate more equitable access to quality experiences with computers in schools. This is a clear advantage of Type A systems.

Another advantage possible in Type A and B systems is the support of large-scale telecommunications networks connecting all units in the jurisdiction to each other and to potentially rich data sources and exchanges with resources outside of the country. Trying to set up telecommunications links individually is prohibitively expensive and time consuming for all but a few settings although the educational advantages of the use of such links are frequently predicted.

Finally, dissemination of information can be most efficiently handled from a central level, as can the organization of periodic large-scale conferences for teachers and other professionals. Type A and B seem most equipped for this, although Type C systems can well handle the latter kinds of events.

¹⁰ See Becker; Carnoy and Loop; and Collis, 1985.

4.6 Application of the model within the context of educational infrastructures and resource scarcity

A few major criteria emerge from the previous discussion that can be useful to predict the likely outcomes of computer education policies. Our discussion will now concentrate on the application of the model relative to the structure of existing educational systems and the level of economic development within countries.

4.6.1 Existing educational infrastructures.

From a structural point of view, a critical aspect is the fit between the computer education policy and the degree of centralization of school systems. Types A and B policies can only be conceived and implemented in fairly centralized educational systems, while types C and D can probably work in both centralized and decentralized systems. The only exceptions would be systems so centralized that they would not allow schools to experiment with computer-related projects.

The existence of a compatible infrastructure is a major constraint to the success of any type of computer education policy. The educational sector and the educational markets are seldom sufficient to justify and support a computer-related industry. To succeed, computer education policies have to rely upon hardware, software, maintenance, telecommunications and training, among other factors. Computer-education programs can help, but not substitute for the existence of such support systems that include universities, industry, and technicians, as well as vendors and suppliers of goods and services. Even though this is critical for Type D policies, it seems to be also true for the other types. Moreover, governments can hardly be expected to operate more efficiently than the private sector—and this is particularly true when it comes to manufacturing and maintenance.

4.6.2 Resource scarcity.

Economic considerations create major constraints for the type of computer education policy more adequate for a given country. Wealthier countries can afford virtually any type of policy, as the resources spent on computers will not sacrifice other essential school inputs. So far, however, no country, even those with policies closer to Type A, has achieved a level of dissemination and usage of computers in schools so as to result in a qualitative difference in the educational process. The cost of hardware—which is given preeminence in the public debate that usually precedes the

launching of computer-related policies—soon becomes a minor component of a national effort, consuming no more than 15–20 per cent of the total budget. In small, homogeneous, wealthy countries such as Scandinavia or Singapore comprehensive policies could possibly succeed.

However, even in other wealthy, but large and less homogeneous countries, it is likely that the available resources will not be enough to make a comprehensive program work, beyond providing very minimal student access to computers and very limited resources for teacher training and support. Moreover, countries attempting to implement very ambitious, centralized, uniform programs run the risks of rigidity and of implementing policies that soon become outmoded or inappropriate at the local level. In the case of a few countries that followed this model, unwarranted promises remained unfulfilled, and comprehensive programs are being replaced by more modest, targeted, and localized initiatives.

4.6.3 Application of the model in the context of resource scarcity.

In the presence of resource constraints, what can be expected from the four categories of the model? Even in the presence of great effort, Type A policies will likely lead to only partial implementation within a country, with some components receiving more attention than others. In fairly unequal societies, as in Latin America, it is likely that in attempting to implement such policies urban schools would benefit more than poorer, typically rural schools, thus exacerbating existing inequalities of educational opportunities.

The results of Type B models under conditions of scarcity are extremely dependent on the specificity of the objectives and its compatibility with the existing infrastructure, including human, physical, and financial resources. The clearer and narrower in scope the national computer education objectives are, the more likely it is that they can be achieved. For example, so far Japan has been very cautious with the use of computers in schools, but its policies have been very consistent in the sense of giving clear priority to secondary, technical education areas. The EDUCOM program in Brazil is another example of a country that until recently has been concentrating its scarce resources in a few university centers, to build up software development capacity and the ability to implement capabilities and the ability to implement computer-

education programs in schools. The now-completed MEP (Microelectronics in Education Program) project in the UK illustrates a country's effort to build up both large-scale and local-level capabilities to develop and experiment with the use of computer software in schools.

Type C policies focus on process, rather than on outcomes of specific interventions. Pilot projects are seen as opportunities to build up national capabilities to learn. In extremely poor countries, such policies may only require a small group of highly qualified people to monitor the state of art in other countries, and perhaps to develop some minimum skills to understand and operate with microcomputers and education software. Type C policy will succeed to the extent that the various components involved in using computers in education are competently handled. For that to happen, Type C policies require the development of strong research and evaluation bases, sufficiently diverse pilot projects to generate opportunities to meet new challenges, and a fairly open flow of communication between projects and the people involved in them. It can be an appropriate model for countries with limited resources but willing to learn and gain some experience with the use of computers without having to commit massive resources for such initiatives. The Minerva Project in Portugal and the computer education program in Kenya illustrate how to develop some simple mechanisms that enable a country to learn from small-scale experiences.

Type D policies might succeed in both extremely rich and extremely poor countries, but be less likely to succeed in those in between. In the first situation, it is but another instance of the market approach to educational innovations. Learning may not accumulate as far or as organized as one might want, but diversity, creativity, and competition might eventually generate effective models of practice. In contrast, in extremely poor countries where governments can do little or nothing at all in this field, local, uncoordinated initiatives might do some good, and very likely no damage, particularly if they do not consume scarce government budgets. In such countries it would take massive investments in computers to create any additional inequity in the education system. In mid-income countries, totally uncoordinated resources might not be sufficient to create markets of competencies and competition, but may be strong enough to put unwelcome pressure on government budgets and compete with resources that might be more effectively and equitably appropriated to other items.

4.6.4 General comments on national computer policy and resource scarcity.

Knowledge about computers in education still relies more on hope and faith, rather than on hard evidence. This being a relatively new field, sound research has been very limited and typical interventions have been dependent on specific contexts. Moreover, the nature of schooling itself has prevented a broader exploration of the full potential of computers. So far the experience shows that to be successfully introduced in schools, software has to be closely associated with curriculum objectives and approaches, and accompanied by specific teacher training. This however constrains experimenting with other potentially creative uses, such as interdisciplinary approaches and the teaching of higher-order skills, both of which are seldom dealt with in typical school situations. Given this situation, even wealthy countries with no budget constraints would be ill-advised to engage in broad, massive, computer-education programs. At the same time, no developing country will risk too much if it does not engage in such massive computer education programs. However, given the potential of microcomputers and the time it takes to learn a relatively complex technology, countries might benefit by adopting less expensive policies, as discussed in the paper particularly in the Type C context. Small-scale experimentation is important, especially in such a rapidly evolving field, but should be done in the context of some kind of national framework for at least the rudiments of policy and support. There is, of course, no answer pertinent to all countries.

5. Questions for further discussion within the context of the model

We conclude with some questions about national policy with respect to computers in education which are frequently being asked. For each of these questions, we think it could be profitable to consider the sort of response that could be made by countries associated with each of the four Types in the model. The exercise might be helpful in choosing an orientation for a policy type within one's own country. The model will only have utility to the extent to which it can help channel thoughts and experiences relative to real-world policy issues such as the following:

1. Under what organizational conditions are computers most likely to be associated with desirable educational outcomes?

2. Under what conditions can the use of computers in schools contribute to the overall economic and social needs of a country?
3. Under what conditions are computers a cost-effective investment?
4. To what extent can computers supplement teachers, or serve in place of non-existent teachers?
5. What computer-related activities are most effectively coordinated at the national level? at the local level?
6. What will we use as indices to measure the effectiveness of our policies with respect to computer use in education?

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