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ABSTRACT

The survey reported on in this document addressed itself to discovering what kinds of quantitative models have been developed and implemented for educational decisionmaking during 1965-72, and what planning questions they are intended to answer; where these models have been implemented and to what extent they are being used; and the cost of such models. A total of 126 questionnaires, with an accompanying explanatory letter, were sent out--61 to large school boards, 44 to universities, and 21 to educational system authorities. The survey results presented here are divided according to the three types of institutions considered and by geographical area. Tables of summary data and a sample survey questionnaire and explanatory letter are included in the appendix. (Author/DN)

REPORT OF THE SURVEY OF CANADIAN USERS OF MATHEMATICAL MODELS FOR EDUCATIONAL DECISION MAKING

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The Ontario Institute for Studies in Education

1973

Report of the Survey of Canadian Users of Mathematical Models for Educational Decision Making

This survey was designed to provide material for a speech to be made by the author at the annual conference of the International Society of Educational Planners held in Mexico City, June 28-30, 1973 as part of the proceedings of the American Association for the Advancement of Science. The paper entitled "Canadian Experience in the Application of Quantitative and Mathematical Models for Educational Planning" was one of six scheduled for the session entitled, "Quantitative Aspects of Educational Planning". It was based to some extent on the personal knowledge and experience of the author and her colleagues in the Department of Educational Planning, the Ontario Institute for Studies in Education[1] and on reports in the recent research literature but even more on the findings of this survey. The paper dealt with Canadian experience on the use of quantitative models over the years 1965-1972 under three headings:

1. What kinds of models have been developed and implemented? What planning questions are they intended to answer?
2. Where have they been implemented? To what extent are they being used?
3. What has been their cost?

Some 126 questionnaires were sent out with an explanatory letter,[2] 61 to large school boards, 44 to universities, and 21 to educational

[1] An institute affiliated with the University of Toronto, Toronto, Canada.

[2] Copies of the questionnaire and letter as well as lists of the samples are included in the Appendix.

system authorities (Departments or Ministries of Education in the ten provinces of Canada, Higher Education Councils or Commissions). The letters were addressed personally to the minister, the university president, or the director of education but the replies generally were from directors of research, or of the planning or the data processing department. A follow-up was made of some of the non-respondents in order to ensure replies from all provinces. No general follow-up of non-respondents was attempted, and we do not claim that the sample is "representative" of all educational agencies in Canada. We considered, for example, that only the larger authorities would have the computer resources to make the use of quantitative models economic. Therefore the small school boards and universities are not represented in the sample in the same proportion as they are to be found throughout the country. Certain small jurisdictions were surveyed, as the list indicates, but few had any experience to report. Thirty-nine of the 44 universities or colleges replied to the questionnaire. The percentage response by province was as follows:

Province	No. of Universities or Colleges Surveyed	Number Replying	Percentage Response
Newfoundland	1	1	100.0
P.E.I.	1	0	0.0
Nova Scotia	3	3	100.0
New Brunswick	3	3	100.0
Maritimes Sub-total	8	7	87.5
Quebec	7	6	85.7
Ontario	16	13	81.2
Central Canada Sub-Total	23	19	82.6

Province	No. of Universities or Colleges Surveyed	Number Replying	Percentage Response
Manitoba	3	3	100.0
Saskatchewan	2	2	100.0
Alberta	5	5	100.0
British Columbia	3	3	100.0
Western Canada Sub-total	13	13	100.0
Total	44*	39	86.6

Seventeen of the institutions which replied had no experience of models to report.[3] Some of these had, in the words of one president, "...made attempts, none of which have been successful." In one other case the president confirmed, "We have a model, of course, but attach no figures to it." Eight other universities also must be considered to have reported "no models" although they either referred to design work which had been conducted at their institutions or to on-going efforts not yet well enough developed to be of use. For example, J. H. Sword, Vice-President, Institutional Relations and Planning, of the University of Toronto referred to the pioneer work on the CAMPUS model of Professor Richard Judy and of Mr. Bert Hansen, now research director for the

*Note: Only 43 institutions were surveyed but Lethbridge University which did not itself have experience in the use of quantitative models not only returned a questionnaire marked N/A but apparently passed on a copy to the Lethbridge Community College of which it once was a part. The Community College reported on two of its models. Similarly, Brock University did not reply as a university but reported a model used by its College of Education to predict enrollment and simulate budgets. The only college which was included in our sample was the Ryerson Polytechnical Institute, Toronto, which failed to reply.

[3] That is, either returned the questionnaire with N/A written on it or sent a letter saying they had "not in the past used mathematical models in making educational decisions nor [were they] doing so now."

Council of Ontario Universities. The president of Memorial University, Newfoundland reported that they had "considered using the Resource Requirements Prediction Model (RRPM) from the National Centre for Higher Education Management Systems, Western Interstate Commission for Higher Education", that their data files were now such that use of the model was feasible, and that they hoped to undertake a pilot study in 1973. Carleton University in Ottawa, Ontario reported that data banks on their staff, students, space and financial needs had been developed in the hope of being able to undertake simulation of the effects of various management decisions, but thus far they had in use only a computerized time-tabling system. The Vice-President, Planning, of the Université de Montréal referred to a number of research activities on which it would be premature to report. The Director of the Computer Centre of the Université de Moncton reported that they were in the process of organizing the data base required for a mathematical simulation model and that it would be at least two years before they would be "ready to initiate the use of such models in our planning."

Among the N/A (not applicable) or all-but-N/A university responses, several made mention of unsophisticated enrollment prediction models, but since they gave no details of the design or use of the models it was assumed that they had not been developed beyond the stage of academic interest. Table 1 shows the number of universities surveyed and the number reporting N/A or all-but-N/A, by province. It may be seen that there is little activity reported in eastern Canada--i.e., in the Maritimes and in Quebec, but probably for different reasons.

The universities of the Maritimes are small; they have not found it necessary to use such planning tools as quantitative models. We were surprised to find that such large English language institutions of Quebec as McGill University reported no experience in the use of models. Possibly as the president of one of the western Canadian Universities reports somewhat ruefully, they find their "Institution [is] not conditioned to use this type of model for on-going operative purposes. The human problem!" Considerable activity seems to be under way in the French language universities of Quebec but only the Université du Québec is ready to publicize its results. In Ontario all the universities which receive public financial support and the Ryerson Polytechnical Institute were surveyed. Only four reported that they were using a number of models. The largest, the University of Toronto,[4] referred to the pioneer research experience of Professor Richard Judy but disclaimed routinely using quantitative models in making its decisions. We characterized the Ontario universities as old and new (i.e., established before or after 1945) and small and large (under or over 10,000 full-time students enrolled in 1972/73). Two of the nine old institutions and two of the seven new institutions reported activity. Two of the four large and two of the twelve small reported the use of models. On the basis of our returns we would not characterize the use of mathematical models as "common" among Ontario's universities.

[4] With 28,150 full time students in the academic year 1972/73 the University of Toronto represents 19.6% of the full time undergraduate and 33.5% of the full time graduate students of the province of Ontario. (Figures are taken from preliminary report of the Ontario Ministry of Universities and Colleges.)

The universities of the western provinces seem more receptive to the use of models in making educational decisions--or perhaps their form of internal administration makes it easier to implement such models within their decision making procedures. Whatever the explanation, more models were reported as being in use, although--as the section of this report on the types of model reports--most of their models are adaptations of ones which have been developed in the U.S. In other words the reports of the western Canadian universities seem to point to administrative adaptability rather than creative design innovation.

Three universities in Manitoba were surveyed, the largest and oldest reporting experience, two small new ones reporting N/A. In Saskatchewan limited experience was reported involving both campuses of the University. In Alberta both the large universities (in Edmonton and in Calgary) reported extensive experience. The Universities of Lethbridge and Athabasca reported no experience. In British Columbia only Simon Fraser University reported its experience.

For Canada as a whole the survey revealed a rather surprising situation. We had reasoned that only the very large institutions, those which undertake the lion's share of all types of university-based research in Canada, would have the human and computer resources to design and use quantitative models. We expected to hear that McGill, Laval and the Université de Montréal in Quebec; that Toronto, Queen's and Western (and possibly the University of Waterloo because of its

research interest in mathematics and computer sciences) in Ontario; that the University of Alberta (Edmonton) and the University of Calgary in Alberta; and the University of British Columbia dominated the field. Not so. However enterprising their professors have been in the research and design stages of quantitative models, with the exception of the two universities in Alberta, these institutions are not *using* models.

The university use of quantitative models which is described herein is based on the experience of 11 institutions which reported several models each. Most not only completed one questionnaire for each model but also sent reports or publications describing them in detail. Table 2 shows the distribution of these institutions by Canadian province and the number of models reported. The problem of interpreting the table is one of definition. What in one university might be considered one comprehensive "model", in another has been reported as a set of two or three, according to the specific tasks each sub-model can accomplish. Thus in one case the RRPM 1.6 (developed by The National Center for Higher Education, WICHE) is reported as one package and in another case as a cost estimation model, an enrollment prediction model, and a model which makes decisions about programs and provides individualized student timetables. The reply submission of the Director of the Office of Institutional Research, University of Alberta, illustrates the difficulty. His letter is indicative of the level of "modelling" work in the few institutions which seem to be

taking a serious interest in their actual use. He writes, "We've had some difficulty in providing a university-wide reply [to your letter] since, to the best of our knowledge, there is no one decision-making model in existence on our campus." However his report covered:(1) an enrollment projection model used to predict the transition from Alberta high schools to first year university by a transition coefficient technique; (2) an enrollment prediction model used to derive short-term, upper-year undergraduate enrollments by faculty; and (3) a staff estimation model, patterned on the technique of induced course load mix as used in the WICHE models which estimates staff requirements for a given mix of enrollment by faculty, discipline and grade. He also referred us to the work of Dr. D.M. Richards of the Department of Educational Administration, which uses a modified RRPM for making college enrollment projections, the work of Dr. D. Ouon of the Faculty of Engineering which uses a predictive model to estimate enrollments in engineering, and the work of Professor A. McGeachy of the Faculty of Business Administration and Commerce which simulates the effects of student program choices in that faculty.

The actual number of models a university thinks it is using, whether one comprehensive model or a set of related models, is unimportant. What is more to the point is the confusion between experience in "using" a model, and work on the design of one which may have been used to generate some numbers for a reform commission or as a "demonstration" but can hardly be said to have become part of the regular operations of

the institution. We have tried to concentrate on the reports which indicate general use.

Of the 61 large school boards surveyed, 45 replied but four replies (which were N/A) could not be identified because the board official did not write its name on the questionnaire. The percentage response by province was as follows:

Province	No. of School Boards Surveyed	Percentage Response
Newfoundland	2	0.0
P.E.I.	1	0.0
Nova Scotia	3	66.6
New Brunswick	3	66.6
Maritimes Sub-total	9	44.4
Quebec	12	33.3
Ontario	27	77.7
Central Canada Sub-total	39	64.1
Manitoba	5	100.0
Saskatchewan	2	100.0
Alberta	3	66.6
British Columbia	3	100.0
Western Canada Sub-total	13	92.3
Total	61	67.2

Except for the province of Quebec, the response of school boards was satisfactory: thirty-one reported that they had no experience of using quantitative models in managing their systems and 3 regretted they could be of no assistance because, although they had a computerized

system for "assigning students to programs in our secondary schools", or preparing "individualized student timetables to ensure as far as possible uniform class size by subject", or scheduling "classroom use and teacher load", or "reporting student progress", they did not regard them as quantitative models. They regarded these as data processing operations rather than models because they were used on a routine administrative basis but they were not used for planning or to simulate the effects of various regulatory decisions. Eleven boards considered that they were using quantitative models and furnished detailed descriptions of them, most having implemented more than one model. The difficulty in assessing the responses is that in many cases the detailed replies of some boards include computerized timetabling and scheduling systems which are probably very similar to the ones dismissed as "not applicable" by other boards. The difference obviously is in the "eye of the beholder". It may also reflect a difference in use of the same management tool. As far as we can judge from notes and comments attached to the questionnaires some boards link the elements of their computerized information system so that it can consider questions of allocation of students, staff and space and produce estimates of cost. Not all these boards had *all* elements of a simulation or prediction model but they seemed to have the main components and made regular use of them for program and budget decisions.

At the level of local school systems Canadian experience, as reported in this survey, is to be found mainly in the large systems of

Ontario--the area boards of Metropolitan Toronto,[5] and the urban systems of the cities of London, Hamilton and Ottawa. From our personal knowledge we would consider that some of the large county boards of education in Ontario (such as Waterloo, Peel, York and Halton) had had no less extensive experience but not all were part of our sample and others seem to have misunderstood our inquiry and reported N/A. This report probably understates the experience of Ontario school boards. Apart from Ontario, the only province where the large urban school boards appear to be making use of quantitative models is Alberta where the officials of the Edmonton and Calgary boards sent in full reports.

Table 1 shows the number of school boards surveyed in each province, those reporting no experience and some experience of the use of models, and those failing to report. It should be noted that the sample was not in any sense representative of *all* types and sizes of local school authority in Canada. Only the boards serving large cities across Canada, and in Ontario large municipal and regional systems were included. However, replies were received from the major Canadian cities--Montreal, Toronto, Hamilton, London, Ottawa, Winnipeg, Saskatoon, Regina, Edmonton, Calgary and Vancouver. The detailed experience reported herein is that of 11 large school systems, most of them to be found in Ontario. Table 2 shows the number of models

[5] Particularly North York, Scarborough and the City of Toronto.

reported by each board. As with the data from the universities the problem in interpreting the school board responses was to try to decide when a report refers to a system with a set of sub models, or a number of distinct models which are used independently for a series of tasks. As will be seen when the types models used by school boards are discussed, the range of models is similar in each jurisdiction. They tend to include a student data file and a teacher data file, used to predict program choices, prepare individual timetables, report on student progress, equate class size and allocate teaching load, and match teaching spaces to groups of students and teachers needing classrooms. Sometimes they simulate costs for budget planning. Sometimes they simulate instructional costs for teachers salary negotiations. Many Boards reported such mundane "models" by means of our questionnaire, but also sent us papers or reports describing their latest efforts which used the files to optimize students first subject choices, or optimize prime time use of specialized classrooms. A few sent us publications describing in detail models which involved computer mapping of attendance boundaries in order to optimize the use of classrooms in jurisdictions which were experiencing a high level of migration, a system of analysing apartment dwellings to predict student yield for an enrollment prediction model, a budget simulation and decision-making model disaggregated to the level of specific educational programs, and a simulation of guidance services for program development and costing.

We had no choice but to judge from the replies to the questions on use, cost and personnel employed whether the models described were experimental or of peripheral importance and only occasionally employed, or whether they had become a regular part of the agency's educational decision-making process. From our own work and that of colleagues in the Department of Educational Planning, we are aware of quantitative models used by school boards which were not part of our sample. For example that of Mr. Bryan Elwood and Mr. Ted Vangel designed for the Waterloo County Board of Education. This is a geo-coded data system, based on the student's home address, which will allow the computer to simulate attendance boundary changes to optimize the use of existing physical facilities, minimize the teacher travel time for special programs shared by schools, or examine any such policy decision where the use of space and location of programs (and hence of children and teachers) is being traded against transportation costs. This SAMPS system appears to be very similar to the MAPS system reported by the Ottawa Board.

The system authorities which we surveyed were a mixed lot. Questionnaires were sent to 21 persons including the Deputy Ministers of Education in the ten provinces, the Deputy Ministers of Higher Education or the Councils of Higher Education in provinces where they existed, and a few other agencies concerned with higher education.

Seventeen replied, the percentage response by province is as follows:

Province	Number of System Agencies Surveyed	Number Replying	Percentage Response
Newfoundland	1	1	100.0
P.E.I.	1	1	100.0
Nova Scotia	1	1	100.0
New Brunswick	2	2	100.0
Miscellaneous Atlantic[1]	1	1	100.0
Maritime Sub-total	6	6	100.0
Quebec	1	0	0.0
Quebec Miscellaneous[2]	2	0	0.0
Ontario	2	2	100.0
Ontario Miscellaneous[3]	1	1	100.0
Central Canada Sub-total	6	3	100.0
Manitoba	2	1	50.0
Saskatchewan	2	2	100.0
Alberta[4]	3	3	100.0
British Columbia[5]	2	2	100.0
Western Canada Sub-total	9	8	88.9
Total	21	17	81.0

The Deputy Ministers of Education in Newfoundland, P.E.I., Nova Scotia, New Brunswick and British Columbia had no experience to report. Manitoba's models (simulating the effects of services provided for student transportation, and predicting population and student enrollment for the purpose of preparing financial estimates) are at

[1] The Association of Atlantic Universities.

[2] Fédération des CÉGÉP and the Association des Collèges du Québec.

[3] Council of Ontario Universities.

[4] Includes the Alberta Universities Commission and the Alberta Colleges Commission now defunct.

[5] Includes the Higher Education Council.

the development stage. The Ontario and Alberta Ministries described a large number of models now being regularly used and Saskatchewan reported two.

Of the 11 ministries and agencies surveyed which deal with higher or further education, 7 replied to the questionnaire. Again the activity seems to be concentrated in Ontario and the western provinces, in this case in British Columbia. The Association of Atlantic Universities expressed interest in the use of models, particularly some uniform accounting system among its members which might provide the base for budget simulations, but no work has been undertaken as yet. The New Brunswick Commission on Higher Education had no experience to report; nor had the Department of Continuing Education in Saskatchewan. The Quebec Ministry's Council on Higher Education, the Fédération des CÉGÉP and the Association des Collèges du Québec all failed to reply. We were told that in Alberta the Universities' Commission is being disbanded. It will be replaced by a Department of Advanced Education and it is presumed that the new Ministry will continue work on post secondary student flow models which are now in their design phase but no models have been implemented as yet.

The Ontario Ministry of Colleges and Universities reported the CAMPUS model which has been used for planning the system of Colleges of Applied Arts and Technology since 1969. From the research department of the Council of Ontario Universities we obtained information on four models, one of which is still in the design stage. The British Columbia Post-Secondary Education Enrollment Forecasting Committee

reported details of its enrollment forecasting model.

Even the most superficial comparison of the system agencies' models with the institutional models of the universities or those used by local school authorities reveals their differences in emphasis. The systems' models are designed to consider inter-institutional or inter-budget-unit allocation questions, to monitor minimum levels of support or service, to predict service demands and estimate the costs of alternative policies. Contrary to what we had expected, the modelling work of the Ministries of Education in the two most experienced provinces (Ontario and Alberta) was much more extensive and sophisticated than that of the Ministries for Higher Education. Possibly the traditional institutional autonomy of Canadian universities militates against the development of quantitative models for their systems planning. Only in a very limited sense can they be said to be systems. In any case such higher education models as exist seem to be limited to logistics planning questions such as matching estimated numbers of students and teachers with space requirements, or comparing the unit costs and staffing of programs from one institution to another, or estimating the effect on total government investment of manipulating some aspect of the unit grant system. Table 1 shows the number of system agencies surveyed in each province, those reporting no experience, some experience, or failing to reply. Table 2 shows the number of models reported by each agency. The system agencies are distinguished as those responsible for schooling or those responsible for higher education.

The geographical distribution of system experience in using models is similar to that which applied for universities and school boards. If a foreigner wished to learn quickly of Canadian experience in the use of quantitative educational models, he could get a fairly accurate national picture by visiting two provinces (Ontario and Alberta) and concentrating his inquiries in three large cities (Metropolitan Toronto, Calgary and Edmonton). He need only obtain reports and publications from half a dozen large school boards, three or four universities, one or two research units (such as the Council of Ontario Universities and the Ontario Institute for Studies in Education) and interview three Deputy Ministers (those of Education and Colleges and Universities in Ontario, and Education in Alberta). Considering the decentralized nature of educational authority in Canada[6] the uneven distribution of the use of, even apparently of interest in, quantitative models for the management of this vast public service is rather discouraging. One can scarcely, with credibility, speak before a foreign audience of Canadian experience in this field.

Having described the response to our questionnaires we shall now comment on the information they contained.

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[6] Ten independent provinces, exercising autonomous power in education, 47 universities and 122 colleges which act as independent institutions, and approximately 275 local school powers exercising considerable control (within a variety of provincial Education Acts) over the schools of their region.

Purpose

The purpose of the models was described by their title and the brief description given in reply to question 4. It soon became evident, in checking the replies which gave full details and the replies which at least gave a title and a two or three sentence description, that a serious problem emerges in trying to decide "what is a model". Much of the reporting involved linear programming models of a fairly recognizable type. There were other cases of computerized data systems which obviously were elements of a system of models, but whether they were used to simulate conditions and effects before policy decisions were taken, whether they were used to allocate required resources after general policy decisions were taken, whether they were used as administrative monitoring and control devices to ensure the proper implementation of plans--in other words whether they were used as decision-making models--could not be attested from the brief replies to this questionnaire. Some other questions of the instrument, apart from the description (particularly those discussing the personnel involved in the design and operation of the model and those reporting costs) provided further indicative evidence of probable use of the model. Some respondents supplemented the questionnaire with copies of internal or published reports which were very useful. Detailed printed or mimeographed reports were received from the Ontario Ministry of Education and the Ontario Ministry of Colleges and Universities, the Council of Ontario Universities, the Carleton Board of Education, the Ottawa Board of Education, the City of Toronto Board of Education, the

University of Alberta, the University of Calgary and the British Columbia Post-Secondary Education Enrollment Forecasting Committee. We decided to take at face value all questionnaires which were fully completed--so we treated them as quantitative decision-making models, even though they may have been used simply as routine data processing systems.

The models reported seem to fall into three types:

(a) Resource prediction devices which enable an institution to simulate costs and prepare budgets. The most widely used of these are the models developed by the National Center for Higher Education Management Systems (NCHEMS) at WICHE in Boulder, Colorado, U.S.A. We were not surprised to learn that these had had wide acceptance in western Canada. In many facets of educational tradition our western provinces closely follow American developments. The RRPM 1.6 was most frequently reported. When it is used to simulate future costs it is driven by a detailed prediction of enrollment. When it is used to allocate current resources or realign budgets, it works from registered enrollment. Input into the model requires student numbers by course, regulations governing course choice, staff resources regulations governing staff use, space resources and loading factors, salary and other costs. The model then permits the calculation of numbers of staff, classrooms, etc. (and ultimately dollars) for a given series of programs and a given level of service.

(b) The models of our second category optimize some factor or policy as defined by the institution or system. Thus, for example, a grants

simulation model used by a provincial government not only will demonstrate the overall anticipated costs for the following year but might demonstrate the best mix of local and provincial cost sharing between boards of different sizes, say, and the central government. Or a space model might optimize, for shared use by the schools of a region, the use of supply teachers, or guidance teachers, or modern language laboratories. The most common optimizing model found among school boards is a scheduling model. Not all scheduling models optimize but many have this characteristic. We suspect that many school boards use the scheduling algorithms only to produce individualized student timetables in the high schools once the students' registration has been completed and the program mix for the coming year is known. We would characterize this as a data processing model rather than a decision-making model. And many school board respondents obviously worked from much the same definition, writing across our form "N/A except for student timetabling, reporting and recordkeeping". Such replies were particularly common among the N/A responses of Ontario school boards. The Ontario Ministry of Education reported a student scheduling system which took some four years to develop and implement, and which now has been operating for three years with three hundred schools as clients. This model prepares individual student timetables that optimize their first subject requests. The Alberta Department of Education and the Saskatchewan Department of Education report similar models. It is evident from the replies that most large secondary schools in Canada have a computerized scheduling system and most such systems have an

optimizing feature--i.e., they calculate the program mix most likely to give the largest number of students, the highest number of first subject choices at a given level of difficulty, and they calculate the best time period timetabling mix for the fullest use of space according to the students' subject choices which have been permitted. And it is evident from the detailed reports which were submitted that boards like that for the City of Toronto use these scheduling models as simulators to test the effects of various proposed policy regulations governing student programs, the use of teachers, teacher load and space requirements.

(c) The models of our third broad category might be described as predictive models. To some extent, of course, the models referred to above "predict" in the sense that they calculate, say, future cost levels, or future "load" levels given a certain volume of service under certain regulations. But they are driven by an initial set of numbers, usually student numbers, which are the output of the prediction models. The most common (in most cases the only) prediction model described by an agency which submitted half a dozen questionnaires was an enrollment projection model. We suspect that this category of models is grossly under represented in this survey for two reasons: (1) many projection "models" are not considered as true models by institutions or agencies, and (2) although they are "run" periodically and generate estimated enrollment numbers they are regarded still as experimental. We questioned the heads of agencies (Presidents, Directors, Deputy Ministers) about their <u>use</u> of models, and most of their detailed replies concerned models which had been running for several years, or had been in a process of being designed and implemented for a long

time. Particularly in universities, we know of models which are still regarded as being in an academic research stage, and which might be characterized as predictive. For example, no agency reported a model predicting student subject choices, but we know there is considerable research work going on--particularly in Alberta--analysing student preferences. The only reference we received, which might be related to the long standing research work of Professor Steve Hunka of the University of Alberta, was a model of the Alberta Department of Education used to determine item difficulty in program materials, examinations and tests, and used for student placement and diagnostic curriculum decisions. A number of enrollment projection models were reported. The most extensive is probably the model of Professor Watson and Mr. Quazi of O.I.S.E., run on contract for the Ontario Ministry of Education for the past four years to produce ten-year enrollment projections for each of 60 county and urban Boards of Education in Ontario. The most detailed projection models are those reported by the Metropolitan Toronto area boards (City of Toronto, Borough of North York and Borough of Scarborough) which incorporate into their prediction formulae demographic and housing variables, as well as student flow within the schools. These models have been *in use* for several years. The most interesting new model about to be implemented is that reported by the City of Toronto Board entitled "Hybrid and Normal Relative Accessibilities Model". It was developed for other purposes by the Town Planning Department of the City of Hamilton, Ontario. The Toronto Board of Education is modifying it for use with the 140 schools of its system. In its pilot stage

they have been using it to study the pupil clientele of two schools only. The purpose of the model is "to quantify the relative accessibilities of schools to their surrounding population". Toronto also reported a model which would describe the distribution of school aged population within its jurisdiction by means of matrix centroids. The purpose of the model is "to improve enrollment projecting by school by examining the effect on predicted numbers of internal migration trends". This model, which is another adaptation from an original developed by the Hamilton Planning Office, is typical of a development in enrollment prediction efforts in Canada. The higher education enrollment prediction models, notably that reported by British Columbia, are also trying to reduce error by "regionalizing" the prediction base. The problem of predicting mobility is not unique to Canada but is particularly acute here. We are a highly mobile people. We are an immigrant country. There has been for decades a considerable transfer of population going on within the country from rural to urban areas and from certain provinces (particularly the east and parts of the prairies) to Ontario and British Columbia in particular, and also to Alberta. This internal migration is unrecorded, except for decennial censuses and periodic estimates which leave a great deal to be desired. Our traditions are strongly opposed to a residence registration system, such as that practised in Sweden or the Netherlands. Only in time of war have our people ever carried identity or registration cards, such as are used in France.

All jurisdictions making enrollment estimates must try to incorporate migration variables into their models. When you have client choice of institution, as in the case of universities and increasingly in the case of secondary schools (because of subject choices) the problem is exacerbated.

From our survey we would say that the models reported as being in actual use fall into these three broad categories. However since we were interested in the purpose as seen by administrators (specifically in what questions the models seem designed to help answer) we devised our own tabulation scheme (see Table 3). We do not make any great claims for this scheme. It is difficult to develop categories which are mutually exclusive. Most of the models carry out a variety of tasks and produce numbers for several administrative uses. We might have used some other widely accepted categorization--for example that used by the OECD survey of quantitative models labels them as descriptive, forecasting, decision-making and simulation models. In other cases the models have been categorized according to the types of equations used (equalities/inequalities; deterministic/stochastic; instantaneous/lagged first order/lagged second or higher order; linear, non-linear, etc.). In others they have been categorized according to the procedures used to solve the model (e.g., matrix, inversion, iteration). The purpose of this categorization scheme was to try to give the non-technical reader of this report (most of whom will be educational administrators) a picture of the range of reported experience which is neither confusing nor distorting.

According to this tabulation the largest number of models used by universities are the general resource allocation models of the WICHE type which enable the institution to match students, teachers and space, and derive cost and staffing figures under various assumed conditions. Considering the range of programs and types of administration in Canadian universities, the range of modelling attempts is very limited. It is clear that however useful these models are in terms of directing administrators' attention to data systems and problems of classification and cost, they have not begun to affect the educational decisions made in universities. They are not used, for example, to consider alternative admissions criteria, performance necessary for credit or promotions, length of acceptable terms for program completion, appropriate examination or evaluation instruments, frequency of evaluation, or program mix in terms of required and optional subjects. The models of school boards are generally system specific and directly related to specific tasks. Their models seem to be more modest and practical in intent; they are probably more immediately useful and more frequently used. This impression was corroborated when we examined the responses on costs and staffing. The experience of school boards reported herein is virtually confined to recurring tasks such as: optimizing classroom use in a large school; minimizing attendance distance for students taking special programs not offered in every school; minimizing teacher travel when a service is offered on a peripatetic basis; optimizing the use of the supply teachers of a "pool" under various policy decisions regarding the use of temporary replacements. Departments or Ministries of Education seem to have

invested in models for two purposes: (1) to provide a demonstration or a service facility for school boards which they might not be able to afford themselves. (For example, the Ontario Ministry has commissioned a transportation model and a teacher cost model which are beyond the stage of research/design but have not yet been commonly adopted. But they also report a scheduling model run for many years as a service with the annual operating costs recovered in the form of client fees.);(2) to estimate the effects on government spending of a change in support policy (such as per capita grants to universities or per capita ceiling restrictions on the spending of boards) or a change in the allocation of investment among different institutions or different programs.

Staffing, Design, Implementation, Use and Modification

In the Appendix Table the replies to questions 5-9, which asked who had designed the models, how long the design and implementation stages had taken, how long the models have been in use and how frequently they have been modified, are reported for each model--each line deals with a model as separately reported. In tables 4 to 8 we show the number of replies, by a series of time or other categories and by type of reporting agency.

One problem in analysing the returns is that the reported experience in the design and use of models does not lend itself to neat tabulation by mutually exclusive states. There is danger of distorting

the picture if we try to make the responses fit into our design. This is an example where an anecdotal type of reporting by "case study" would probably be more appropriate to the subject than the usual survey report. For example, design, implementation, use and modification stages obviously run into one another and progress at times in a sequential cycle and at times concurrently. Nowhere is the evidence more clear than in these questionnaires that "a model is never complete" and that an authority "gets hooked on a model and ends up with a bigger commitment than it bargained for". One authority reports that design, testing and implementation went hand in hand and "it is difficult to accurately establish costs". Another reports "major modifications twice a year and minor ongoing". The terms "ongoing" and "concurrent" are frequently used in the writing of model design and implementation. In another case the explanation for not reporting costs is "it is difficult to separate the cost of ongoing design from operating costs, since the model is being continuously improved through experience". In the case of one model which has been used since 1968 annual modifications have been made. The models frequently are a joint effort--the original having been a commercial product purchased from and implemented by a consulting firm, the present model being the product of endless staff modifications. Where the model described is one of the WICHE series, the modification and implementation time are generally reported, but not the design time.

Table 4 shows that whatever the origin of the design, the bulk of the work is carried out by the agency's own staff. This was true

of 16 of the 26 university reports and 13 of the 28 school board reports. But it was not as true of the reports from higher education agencies. If anything the role of "own staff" has been underplayed. Generally, even with the original commercial product, they work with the consultants to make it institution or system specific. The five IBM models shown here are all scheduling/timetabling routines of well established vintage. The SRG item is the CAMPUS VIII set of models which have been implemented for the Ontario system of Colleges of Applied Arts and Technology. The WICHE models include the Cost Estimation one, the RRPM 1.3 and the RRPM 1.6.

Tables 5 and 6 should be read together. They tabulate the replies to questions 6 and 7 about the length of time taken for design and implementation. One problem in assessing the replies to these questions is that some respondents specified man-weeks, man-months or man-years while others simply reported weeks, months or years without making clear the number of employees involved. (We must take responsibility for this because our example was not sufficiently explicit.) In the Appendix Table and Tables 5 and 6 we have had to "interpret" the responses in order to group them by category. Few of the models took more than a year to design and another year to implement. We found this surprising. The explanation, probably, is that development of the appropriate data system required for the model preceded its implementation and is not included in the reported implementation time. If we eliminate the responses "Unknown" more of the universities' models took longer than

six months to design or modify than was the case with school board models or those of education agencies: the percentages were for less than six months, universities 44%, school boards 53%, and education systems 73%. Two of the reported higher education systems models took over a year to design; of the other four, three took less than six months each and one is still in the design stage. The "time unknown" reply to the design question (Table 5) refers to the ignorance of the reporting agency of the design time spent by the firm from whom the model was purchased. The "time not given" replies to the implementation question arise from the problem of separating design and implementation time or because as yet implementation is incomplete and no estimate of required time was given. The problems of interpreting the implementation time replies are such that we would not take the precise time too seriously.

It is evident from Table 7 that considerable experience in the use of models may be found in a few members of all four types of reporting agencies in Canada. School Boards and Departments of Education, in particular, report models which they have used for 5 or 6 years. For them models have long since ceased to be an "academic gimmick".

It seemed to us reasonable to look at the evidence of frequency of modification in terms of the length of time a model had been in use--the argument being that experience in use reveals needed modifications and most of these models are being continuously improved. The evidence of Table 8 suggests that either the models are very imperfect instruments, or the users have impossibly high standards, or the users

are afflicted with an itch to interfere--15 of the fifty-three models for which information was provided had been modified "continuously" (or words to that effect), a further three (in operation at least one year) had been modified twice per year, and another 13 at least once per year.

Costs

Information on costs is notoriously unreliable when gathered by questionnaire and for 23 of the 82 models reported, no information was given for design or implementation costs. Frequently the respondents have only a very general notion of the amount involved because their responsibilities do not include cost approval. In some cases staff salaries were included in the reported figures and in others only computer time or supplies. Where the model was purchased from some other agency, the cost to the user is more likely to be related to whether the agency is a profit-making one in the private sector or a publicly funded one, rather than to any indicator of magnitude or capacity of the model. A commonly quoted cost for one of the WICHE models, for example, is $50.

We thought it would be appropriate to analyse the reported costs from several points of view:

(1) Design costs by model type (as defined by purpose) are shown in Table 9.

(2) Design costs according to designer are shown in Table 10.

(3) Design and operating costs according to reporting agency are shown in Table 11.

The range of reported direct costs was so great (design from $50 to $110,000; implementation from $75 per year to $1 million in 1972/73) that we had difficulty deciding upon cost categories that would accurately demonstrate their distribution. We decided to use the same categories for all tables and their choice is entirely arbitrary. They are categories of unequal size but they reflect the clustering of reported costs about certain rounded figures like $10,000 or $20,000. In any case the precise figures should not be taken seriously. What is of interest is the large number of models whose design costs were extremely modest and (even more surprising) whose annual running costs are less than one hundred dollars. We have not included an Appendix Table showing the reported costs by model and reporting agency because agencies frequently are sensitive to publicity about costs (which can be easily abused and misrepresented by being quoted out of context). We have followed the usual practice of aggegating and tabulating reports so that nothing which might prove embarrassing to an individual respondent is identified.

The reader should note that we are not "comparing" costs in these tables. It should not be inferred that becasue two IBM models are to be found in the category $5,001-$10,000 and only 1 of the 2 SRG models reported cost less than $10,000 for its design, that SRG models are, therefore, more "expensive". The models reported vary tremendously and we are not necessarily comparing like with like. Table 10 does show, however, that many models cost the users a negligible sum or had no direct cost because they have been acquired from a public

service agency. Models purchased from commercial consultants generally come as a "package deal" to the user with design, implementation and often staff training and data processing services included in the price. Since they are implemented more than once for the same kind of client the return on the initial design investment is very good indeed. The modest reported implementation costs of many models suggest that, once an agency's administrators become convinced of the utility of models and employ research and data processing staff who understand the uses and limitations of models, its employees can fairly quickly spin off models to deal with specific recurring administration questions, test and implement them or drop them (according to some estimate of the success of their effort). This seems to be particularly true of the large school boards. The area boards of Metropolitan Toronto, and the cities of Edmonton and Calgary report as sophisticated a set of models as can be found in any educational jurisdiction, yet the total design cost of the 18 models for which they submitted detailed information was not high. Except for one model costing $10,000 and one of $35,000, design cost varied from "no cost" to less than $5,000. In almost all cases the design work was done by their own staff. In four cases the original model had been purchased from IBM but extensive modifications had been carried out by their own staff. In one case the original had been purchased from Honeywell and in another from SRG (modified by York Computer Services) but again extensive recent modifications had been carried on by "own staff" at very little cost. We were surprised to learn from this survey that more research into the extension of the use of quantitative models in educational planning and administration

is being carried out in school boards than in universities. The few comprehensive and expensive models which were reported had been commissioned by such systems authorities as the Ontario Ministry of Education or the Ontario Ministry of Colleges and Universities. The best "bargain" obviously is the WICHE RRPM 1.6 which for an initial direct cost of $50 provides a system easily adapted to providing solutions for a number of gross allocation questions.

Models Allowed to Lapse

From Table 9 which tabulates cost by "purpose" only five of the models for which detailed information was reported have been discontinued:

The City of Toronto Board discontinued the use of a budget simulator which had been in use for 18 months, because the recent per capita spending ceilings imposed by the Ontario Ministry of Education required a different budget format, thus rendering it obsolete.

The City of London Board of Education discontinued its elementary school enrollment projection (by school) model because of lack of funds to develop it to the desired level of accuracy.

Lethbridge Community College discontinued the use of the WICHE model RRPM 1.3 because they are replacing it with RRPM 1.6.

The University of Western Ontario also reported that it would shortly be discontinuing the WICHE Cost Estimation Model and replacing it with the RRPM 1.6.

The University of Alberta discontinued a staff estimation model which was "implemented for one-time use to provide preliminary staff projections for the University of Alberta's Academic Plan No. 9". Apparently models are modified (even to the point of being almost unrecognizable) rather than discontinued.

Conclusion

The purpose of this mini survey was to provide evidence of Canadian "experience" so that a speech which we had agreed to give before a learned society would be a less personally biased statement than would have been the case had we had to rely only on our personal knowledge of activity in Ontario and on the opinions and contacts of our colleagues in the Department of Educational Planning of O.I.S.E. Except for Quebec, the returns were sufficiently high to convince us that we had indeed heard from all agencies in Canada with any real experience to report. Their questionnaires and reports were sufficiently detailed to enable us to group replies into rough categories which show the distribution of the experience.

What this kind of survey cannot do, of course, is assess "degrees of satisfaction" with the performance of these tools. Only by interview could one ask first the Director of Education, then his Data Processing Manager or Superintendent of Planning, then a number of his area Assistant Superintendents, and then a sample of his Secondary School Principals, the question: "Model X cost your system $30,000 to design and implement.

It costs $5,000 a year to run and you've used it three years. Do you think it was worth it? How do these costs compare with the costs o- doing this task before you had the model? What are the most irritating deficiencies the model has demonstrated? If you had the choice to make would you spend $45,000 ($30,000 + 3 x $5,000) on this type of model? If not, what would you have spent the money for?"

Cost benefit assessment depends on one's perspective and more items than dollars are involved in the equation, although the non-dollar items are difficult to define and measure. A budget simulator which may look highly desirable to the Director of Education may be a source of frustration to the researcher who is all too aware of the limitations of its design and worried about its misuse. It may be a source of endless irritation to the assistant superintendents and principals who have the chore of preparing dates for its runs and see its reports only as a check on the innovations and programs they would like to introduce. The manner of use of a model can increase central decision-making, or it can increase decentralized decision-making where considerable authority has been delegated to administrative sub-units or branches. Only by asking a similar set of questions of officials at different levels in an organization could we try to assess their different experience with the same model and then differing perceptions of models' utility. Unfortunately we had neither the time nor the money for such a research exercise. As a result of the findings of this survey, which cost us some time and a small amount of postage,

the opinions with which we started have been reinforced:

(1) Only a small number of educational agencies in Canada actually have had experience of the regular use of models.

(2) The experience is geographically concentrated in the province of Ontario and in western Canada--particularly in the government departments and large urban school boards of Ontario and Alberta.

(3) The models used by school boards tend to be specific to jurisdictions and to recurring annual tasks--such as definition of bus routes and scheduling of vehicles to minimize costs, classroom scheduling to optimize the subject choices of students, and the use of space at the more popular times of the school day (i.e., classrooms are "fully loaded for peak times" and "under used" at the end of the day).

(4) University models tend to be less task specific. They are most commonly used to advise on "what if" questions by the use of simulation. The most popular ones actually being used are modifications of the WICHE models.

(5) "Own staff" (research or computer services) do most of the design work, even where the original model was a commercial product.

(6) The names of a few consultant firms are reported but much less frequently than we would have predicted. IBM seems to have marketed a most successful scheduling model about 1968/69. The CAMPUS VIII model of SRG is used for the entire CAAT system of Ontario. Professors of the O.I.S.E. Department of Educational Planning, of the University of Western Ontario Business School, of Simon Fraser

University, of the University of Alberta (Edmonton), of the University of Calgary and of M.I.T. have been involved in some of the designs which were reported. But the "big names" of the United States (the Rand Corporation, Brooking's Institute, the University of California at Berkley, Florida State University and the University of Chicago) were notable in their absence. This we did not expect.

(7) The cost data of the survey are not much use. In many cases the cost of salaries has not been included. It is difficult to separate design and implementation costs and many respondents did not even try. In the case of commercial products it is obvious that the price of the models covers a variety of services so that comparison between them cannot be made. The cost of developing an information system appropriate for a particular model is related to its implementation costs and will vary greatly depending on the statistical practices which formerly applied. Generally this is not reported. So in some of these models the cost of organizing the data files far exceeded the cost of the model itself. Nevertheless many modest but useful models are currently employed whose total investment was well under $5,000.

(8) The reports on design time and implementation time can only be taken as indicative because (a) detailed records are only known for work done by an agency's own staff, and (b) the time reports did not always say how many persons were involved (i.e., man-months or man-years). However, the reports have some value in demonstrating that many models could be used within six months of

beginning the design. This takes much of the "mystery" out of these models, reducing them to the status of common administrative tools. Six months would be a quite common time needed even for a minor change in traditional administrative procedure. Many models were found to show an immediate economy. School boards, in particular, reported the estimated saving achieved by the use of a model (e.g. 5-10% reduction in transportation costs was routine for a bus scheduling model). Since many of the routines which the models replace were "hand crafted" (e.g., student reporting, student timetables, teacher timetables and master scheduling for a secondary school) the saving is expressed in terms of the time of highly paid administrators rather than dollars. It does not lead to a reduction in payroll but it frees them for other work involving more personal relationships with the teachers and students.

This survey does not support the hypothesis that large jurisdictions have the resources to design, implement and use quantitative models for making educational decisions. Of the 12 largest Canadian universities (Université de Montréal, Laval, McGill, Toronto, Western, McMaster, York, Manitoba, Saskatchewan, Alberta, Calgary and British Columbia) only the two universities in Alberta and McMaster and Western in Ontario reported models in use. In Ontario one of the smallest universities, Lakehead, reported the development of a cost estimation model. From these replies it seems that many universities and large urban boards whose resources are such that they could design a series

of models for management decisions, have not found their use sufficiently attractive to induce their adoption. As with many other administrative innovations, first must come the conviction that the change is worthwhile. This conviction seems to be very localized in Canada. The foreigner who wishes to discuss the use of quantitative models with officials of school boards, government departments and universities can, by visiting only a few Canadian cities, tap quite varied and extensive experience. For these jurisdictions models are no longer a "gimmick".

TABLE 1

QUESTIONNAIRE RESPONSES BY PROVINCE
AND TYPE OF REPORTING AUTHORITY

Province	Reporting Agency	Number Surveyed	Number Reporting N/A	Number Reporting Experience	No Response
Newfoundland	University	1	1	0	0
	School Board	2	0	0	2
	System - education	1	1	0	0
P.E.I.	University	1	0	0	1
	School Board	1	0	0	1
	System - education	1	1	0	0
Nova Scotia	University	3	3	0	0
	School Board	3	2	0	1
	System - education	1	1	0	1
	- higher education[1]	1	1	0	0
New Brunswick	University	3	3	0	0
	School Board	3	2	0	1
	System - education	1	1	0	0
	- higher education	1	1	0	0
Quebec	University	7	5	1	1
	School Board	12	3	1	8
	System - education	1	1	0	0
	- higher education	2	0	0	2
Ontario	University	16	9	4	3
	School Board	27	13	8	6
	System - education	1	0	1	0
	- higher education	2	0	2	0
Manitoba	University	3	2	1	0
	School Board	5	5	0	0
	System - education	1	0	1	0
	- higher education	1	0	0	1
Saskatchewan	University[2]	1	0	1	0
	School Board	2	2	0	0
	System - education	1	0	1	0
	- higher education	1	1	0	0
Alberta	University[3]	5	2	3	0
	School Board	3	0	2	1
	System - education	1	0	1	0
	- higher education	2	1	0	1
British Columbia	University	3	2	1	0
	School Board	3	3	0	0
	System - education	1	1	0	0
	- higher education	1	0	1	0
Total		125[4]	67	29	29

1 The Association of Atlantic Provinces.
2 Both campuses covered.
3 One community college (Lethbridge) included in this number.
4 Plus second University of Saskatchewan campus, making total of 126.

TABLE 2

NUMBER OF MODELS REPORTED BY PROVINCE AND TYPE OF REPORTING AUTHORITY

Province	Reporting Agency		Number of Models Reported
Quebec	University:	Universite du Quebec	1
	School Board:	Commission Scolaire Regionale de Tilly	4
Ontario	University:	Lakehead	1
		Brock (College of Education)	1
		McMaster	3
		Western Ontario	4
	School Board:	London	3
		Borough of York	2
		North York	1
		Scarborough	4
		City of Toronto	6
		Hamilton	1
		Ottawa	1
		Carleton	1
	System:	Ministry of Education	9
		Ministry of Colleges and Universities	1
		Council of Ontario Universities	4
Manitoba	University:	Manitoba	4
	System:	Ministry of Education	2
Saskatchewan	University:	Saskatchewan	1
	System:	Ministry of Education	2
Alberta	University:	Alberta	6
		Calgary	4
		Lethbridge	2
	School Board:	Calgary	1
		Edmonton	4
	System:	Ministry of Education	6
British Columbia	University:	Simon Fraser	2
	System:	Higher Education Council	1
Total			82

TABLE 3

NUMBER OF MODELS REPORTED BY PURPOSE OF MODEL AND REPORTING AUTHORITY

Purpose of Model	Universities	School Boards	Education Agencies	Higher Education Agencies
1. Student timetabling or scheduling	2	8	2[2]	-
2. Simulation of student course and program choice (and resultant student timetables and schedules)	4	4	2	1[3]
3. Reporting student progress (and resultant placement, guidance or program choice)	-	1	2	-
4. Student flow models (within institution or system variables) for enrollment prediction	2	1	1	2[3]
5. Student flow models (transition models) for enrollment prediction	7	3	3	1
6. Student performance models (linked to tests and placement)	-	-	-	1[3]
7. Student awards models (to simulate costs and awards distribution)	-	-	1	-
8. Teacher timetabling or scheduling (linked with master scheduling or faculty work load simulation)	2	7	2[2]	1[3]
9. Faculty flow models (recruitment, retirement, faculty supply/demand)	1	-	-	1
10. Faculty needs estimate models (apart from WICHE or CAMPUS models)	1	-	-	1[3]
11. WICHE models or modifications of them	10[1]	-	-	-
12. Space or classroom needs models (apart from WICHE or CAMPUS models)	2	-	-	1[3]
13. Space needs (linked to use of schools or attendance areas)	-	4	-	-
14. Space needs (linked to master scheduling)	2	7	2[2]	1[3]
15. Library planning	1	-	-	1[3]
16. Personnel payroll models (apart from WICHE Models)	1	2	-	1
17. Program budgetting, resource allocation or unit cost models (apart from WICHE)	4	7	1	2[3]

TABLE 3 - Continued

Purpose of Model	Universities	School Boards	Education Agencies	Higher Education Agencies
18. Grants simulation models	-	-	5	2[3]
19. Teacher costs model	1	-	1	-
20. Minimum subsidy model (for Teachers Superannuation Fund)	-	-	1	-
21. Escalation subsidy model (for Teachers Superannuation Fund)	-	-	1	-
22. Early retirement model	-	-	-	1
23. Bus scheduling or transportation models (linked to 13)	-	-	3[2]	-

[1] Memorial and Simon Fraser are also "considering" them.

[2] The Ontario model is also used by school boards.

[3] CAMPUS is represented here.

Note: From their description several models fall into more than one "purpose" category, and it is evident that in some cases a set of models has been reported as "one" where an equivalent grouping of linked models has been described as if each sub model were independent. Moreover not all respondents answered every question about every model. So the sums of the categories in the tables of this report are not always identical.

TABLE 4

NUMBER OF MODELS REPORTED BY MODEL DESIGNER(S) AND TYPE OF REPORTING AUTHORITY (QUESTION 5)

Model Designers	Universities	School Boards	Education Systems	Higher Education Systems
Own Staff	16	13	5	4
Ministry or Government personnel (as well as own staff)[1]	-	4[1]	3	-
NCHEMS (WICHE)	9	-	-	-
University Consultants	-	1	-	1
M.I.T.	1	-	-	-
O.I.S.E.	-	-	2	-
S.R.G.	-	1	-	1
I.B.M.	-	5	1	-
Honeywell	-	1	-	-
Memphis School Board	-	1	-	-
City of Hamilton Planning Office	-	2	-	-

[1] Includes assistance to Ministry of Education staff by personnel from such agencies as a government computer services centre. Also includes assistance to school board from a ministry in design of a model used exclusively by them if for a group of boards. In Québec the Service Informatique de Ministère de l'Education designed the models used by Tilly.

TABLE 5

NUMBER OF MODELS REPORTED BY LENGTH OF DESIGN STAGE AND TYPE OF REPORTING AUTHORITY (QUESTION 6)

Design Stage	Universities	School Boards	Education Systems	Higher Education Systems
Unknown[1]	8	9	-	-
WICHE adaptation time 2 months	2	-	-	-
WICHE adaptation time 12 months	1	-	-	-
Less than 6 months	6	10	8	3
6 months to less than 1 year	2	3	-	-
1 year to less than 2 years	4	2	2	1[3]
2 years	2	1	-	-
More than 2 years	-	-	1	1
Not complete; no time given[2]	1	1	-	1

[1] Includes most of the WICHE models and those purchased as a "package" like the IBM products.

[2] In some cases design and implementation are concurrent. In this case no design time was given. In other cases design time was reported but not implementation time (and an appropriate note was attached); in still others an estimation was given for design and for implementation although both were not considered to have been completed. Notes attached to the "length of use" and "modification" questions indicated that for many models no stage is ever accepted as being "complete" and a constant process of adaptation and implementation of modification goes on.

[3] One year spread over a three year period for staff and consultant.

TABLE 6

NUMBER OF MODELS REPORTED BY LENGTH OF IMPLEMENTATION STAGE AND TYPE OF REPORTING AUTHORITY (QUESTION 7)

Implementation Stage	Universities	School Boards	Education Systems	Higher Education Systems
No time given	12	6	2	3
Still being developed	2	-	-	1
Less than 6 months	7	6	5	-
6 months to less than 1 year	3	2	-	-
1 year	2	2	2[1]	1
More than 1 year	-	2	1[1]	1[1]

[1]Concurrent with design.

TABLE 7

NUMBER OF MODELS REPORTED BY TIME IN USE AND TYPE OF REPORTING AUTHOR (QUESTION 8)

Time in Use	Universities	School Boards	Education Systems	Higher Education Systems
Not reported because not yet completely implemented	8	5[1]	1[2]	1
Less than 1 year	4	1	4	1
1 year	6	2	2	-
13 months to less than 2 years	4	2	-	1
2 years	3	9	-	-
More than 2 years	1	9	4	3

[1] Includes one to be discontinued.

[2] Will be in use May 1973.

TABLE 8

NUMBER OF MODELS REPORTED BY TIME IN USE AND FREQUENCY OF MODIFICATIONS (QUESTION 9 BY QUESTION 8)

Time in Use	Modifications Reported									
	No Response	None	Minor[1]	Once	Twice	Thrice	One/yr.	Two/yr.	Frequently[3]	Continuously
Less than 1 year	2	4	1		1				1[4]	2[6]
1 year	4	1					1[2]	1	2	1
1 to less than 2 years	1		1	2	2		1			
2 years	1	2				1	3	1	4[5]	
More than 2 years	1	2	1				3	1	5	2

[1] Or "a little".

[2] "First one now".

[3] Or "many times" or "extensive".

[4] Twice in 6 months.

[5] One reports "every 3 months so far".

[6] Monthly.

TABLE 9

NUMBER OF MODELS REPORTED BY PURPOSE OF MODEL (SEE TABLE 3) AND DESIGN COSTS (QUESTION 10)

Purpose of model[1]	No Cost Given	Less than $100	$101-$1,000	$1,001-$5,000	$5,001-$10,000	$10,001-$30,000	$30,001-$50,000	Over $50,000
1	10				1			1
2	3			3	2	1		2
3	2			1				
4				1	2	1	1	1
5	7	1	2	3			1	
6								1
7					1			
8	7			2		1		2
9				1	1	1		
10		1						1
11	5	2			3			
12	2							
13	1		1	1				1
14	8			2				2
15					1			1
16	1		1			1		
17	3		1	5	3		2	1
18	2			2	2			1
19				1		1		
20			1					
21				1				
22	1							
23	2				1			

[1]Numbered as in Table 3.

TABLE 10

NUMBER OF MODELS REPORTED BY DESIGNER AND DESIGN COSTS

Designer[1]	No Cost Given	$100	$101-$1,000	$1,001-$5,000	$5,001-$10,000	$10,001-$30,000	$30,001-$50,000	Over $50,000
Own staff	11	1	3	11	9	1	2	2
Ministry staff	4			3				
NCHEMS (WICHE)	4	2			1	1		
Univ. Consultants						1		
M.I.T.								
O.I.S.E.						1	1	
S.R.G.				1				1
I.B.M.	4				2			
Honeywell	1							
Memphis S.B.	1							
City of Hamilton P.O.	2							

[1] For details and notes see Table 4.

TABLE 11

NUMBER OF MODELS REPORTED BY REPORTING AUTHORITY
AND COST OF DESIGN & OPERATION

Cost Category	Universities		School Boards		Education Systems		Higher Education	
	Design	Operating	Design	Operating	Design	Operating	Design	Operating
$100 or less	3	-	-	1	-	2[3]	-	-
$101-$1,000	2	3	1	7	-	1	-	-
$1,001-$5,000	3	3	6	2	5	1	1	2
$5,001-$10,000	5	3	1	1	3	1	3	1
$10,001-$30,000	2	2	1	4	1	4	-	-
$30,001-$50,000	1	-	1	2	1	-	-	-
Over $50,000	-	-	1	-	1	2[4]	1	1
No cost given	9[1]	14[2]	17	6[1]	-	-	1	2

[1] In some cases, in addition to saying the design costs were unknown, the agency reported "no direct cost to us" but purchased from WICHE, IBM or whatever for $--. In the latter case they are included in the appropriate cost category, particularly since several not only gave the purchase price but also estimated costs of design modifications done by their own staff.

[2] Explanations given such as "Costs not fully known until properly implemented";"will depend on how much we use it--have only run twice so far"; "insufficient data";"still experimental"; "costs shared by many departments difficult to estimate"; "no direct cost to us".

[3] Explanation that this covered the cost of 2 computer runs which was all that had been carried out thus far. Annual costs would depend on use. Too early to estimate normal annual costs.

[4] Most of cost recovered from school board users.

APPENDIX TABLE

NUMBER OF MODELS REPORTED BY REPORTING AUTHORITY, PURPOSE(S) OF MODEL, AND RESPONSES TO QUESTIONS 3, 5, 6, 7, 8 and 9

Type and Name of Reporting Authority	Purpose(s) of Model (from Table 3)	Question 3	Question 5	Question 6	Question 7	Question 8	Question 9
University:							
Quebec(1)[1]	11	CDC 640	NCHEMS (WICHE)	-[2]	**[4]	-	once
Lakehead (1)	17, 2	IBM 360/50	Own staff	*[3]	-	-	-
Brock (1)	2	Burroughs 5500	Own staff	6 mths.+	**	-	-
McMaster (3)	9, 2, 16, 8	IBM 370/155	Own staff	1 yr.	**	-	cont.
	1, 4	CDC 6400 & IBM 370/155	Own staff	1 yr.	**	2 yrs.	cont.
	9, 19	CDC 6400 & IBM 370/155	Own staff	1 yr.	**	2 yrs.	cont.
Western Ontario (4)	11	IBM 370/145	NCHEMS (WICHE)	-	1 yr.	1/2 yr.	infreq.
	11	IBM 370/145	NCHEMS (WICHE)	-	**	-	none
	4, 5, 17	IBM 370/145	Own staff	2 mths.	**	13 mths.	infreq.
	15	IBM 370/145	Own staff	2 mths.	**	-	-
Manitoba (4)	17	IBM 360/40	Own staff	2 yrs.	3 mths.	15 mths.	-
	11	IBM 360/65	Own staff	-	3 mths.	1 mth.	-
	1, 8	IBM 360/65	M.I.T.	-	-	1 yr.	-
	12	IBM 360/65	Own staff	-	**	-	-
Saskatchewan (1)	11	IBM 360/50 and /40	NCHEMS (WICHE)	-	3 mths.	twice	-
Calgary (4)	11	IBM 360/50	NCHEMS (WICHE)	-	6 mths.	5 mths.	none
	12, 14	IBM 360/50	Own staff	*	-	-	-
	14	IBM 360/50	Own staff	1 yr.	-	5 yrs.	infreq.
	17	CDC 6400	Own staff	2 yrs.	**	1½ yrs.	twice
Alberta (6)	5	IBM 360/67	Own staff	3 mths.	2 mths.	2 yrs.	thrice
	5	IBM 360/67	Own staff	1 mth.	1/2 mth.	1½ yrs.	once
	10	IBM 360/67	NCHEMS (WICHE)	1 mth.	1½ mths.	9 mths.	none
	11, 5	-	-	-	-	-	-
	5	-	-	-	-	-	-
	5, 2	-	-	-	-	-	-

Type and Name of Reporting Authority	Purpose(s) of Model (from Table 3)	Question 3	Question 5	Question 6	Question 7	Question 8	Question 9
University (cont'd):							
Lethbridge C.C. (2)	11	-	NCHEMS (WICHE)	2 mths.	6 mths.	1 yr.	-
	11	-	NCHEMS (WICHE)	2 mths.	6 mths.	1 yr.	-
Simon Fraser (2)	5	IBM 370/155	Own Staff	4 mths.	4 mths.	-	none
	11	-	NCHEMS (WICHE)	1 yr.	-	-	-
School Board:							
C.S.R. de Tilly(4)	16	IBM 370	SIMEQ (M of Ed)	1 yr.	4 mths.	2 yrs.	twice/yr.
	1	IBM 370	SIMEQ	1½ yrs.	6 mths.	1½ yrs.	once/yr.
	2	IBM 370	IBM	-	4 mths.	2 yrs.	once/yr.
	17	IBM 370	SIMEQ	1 yr.	3 mths.	1 yr.	twice/yr.
London (3)	1, 3, 14	IBM 370/155	Min. of Ed.	-	1 yr.	2 yrs.	-
	4	PDP 10	Univ. Consult.	1-2 yrs.	**	-	-
	5	IBM 370/155	Own Staff	3-4 mths.	2 mths.	***[5]	-
Borough of York (2)	1, 8, 14	Honeywell 120	Honeywell	6 mths.	1 mth.	4 yrs.	once/yr.
	17	Honeywell 120	SRG	3 mths.	3 mths.	1 yr.	freq.
Bor. of North York(1)	1, 8, 14	S/360 MOD 30 128K	IBM	-	-	6 yrs.	none
Bor. of Scarborough(4)	1, 8, 13	Honeywell 1200	Own staff	2 mths.	6 mths.	3 yrs.	freq.
	2	Honeywell 1200	Own staff	2 mths.	4 mths.	2 yrs.	freq.
	5	Honeywell 1200	Own staff	2 wks.	1 mth.	1 yr.	freq.
	13	Honeywell 1200	Own staff	-	2 mths.	5 yrs.	freq.
City of Toronto (6)	1, 8, 14	IBM 360/30	Memphis S.B.	-	3 mths.	2 yrs.	none
	2	IBM 360/30	IBM	-	1 yr.	6 yrs.	cont.
	17	IBM 360/30	Own staff	6 mths.	2 mths.	1½ yrs.	once
	5	IBM 360/30	Own staff	*	-	-	-
	13	IBM 360/30	Hamilt. P.D.	-	2 wks.	6 mths.	once/3mths.
	13	IBM 360/30	Hamilt. P.D.	2 mths.	**	-	-
Hamilton (1)	1, 8, 14	IBM 360/30	IBM	-	2 mths.	3 yrs.	none
Ottawa (1)	13	IBM 360/85	Own staff	14 mths.	conc. with design	3 yrs.	once/yr.

APPENDIX TABLE - Cont'd

Type and Name of Reporting Authority	Purpose(s) of Model (from Table 3)	Question 3	Question 5	Question 6	Question 7	Question 8	Question 9
School Board (cont'd):							
Carleton (1)	14, 17	None as yet	Own staff	1 mth.+	**	2 yrs.	twice
Calgary (1)	17	Honeywell 1200	Own staff	½ yr.	**	-	-
Edmonton (4)	8, 17	IBM 370/135	Own staff	2 weeks	2 yrs.	2 yrs	once/yr.
	2, 8, 14	IBM 370/135	Ownsstaff	1 mth.	2 yrs.	2 yrs.	none
	1	IBM 370/135	IBM	-	-	5 yrs.	-
	16, 17	IBM 370/135	Own staff	2 weeks	1 week	3 yrs.	minor
Education System:							
Ontario Ministry of Education (9)	1, 2, 8, 14	IBM 370/155	Own staff	4 yrs.	4 yrs.	3 yrs.	once/yr.
	18	IBM 370/155	Own staff	4 mths.	**	4 yrs.	twice/yr.
	7	IBM 370/155	Own staff	3 mths.	**	6 yrs.	once/yr.
	23	IBM 370/155	IBM	3-4 mths.	3½ yrs.	1 year	none
	18	IBM 370/155	Ministries	½ mth.	2 mths.	6 mths.	none
	20	IBM 370/155	Ministries	4 mths.	1 week	-	-
	21	IBM 370/155	Own staff	6 mths.	2 weeks	1 year	none
	19	IBM 370/155	E.P., OISE	1 yr.	1 yr	1 year	freq.
	4, 5	IBM 370/155	E.P., OISE	1 yr.	conc. with design	4 yrs.	once/yr.
Manitoba Ministry of Education (2)	2	-	-	-	-	-	-
	18, 5	-	-	-	-	-	-
Saskatchewan Ministry of Education (2)	18	IBM 360/40	Own staff	1 mth.	2 mths.	6 mths.	freq.
	2, 3	IBM 360/40	Ministries	3 mths.	2 mths.	2 mths.	twice
Alberta Ministry of Education (6)	3	-	-	-	-	-	-
	5	-	-	-	-	-	-
	23	-	-	-	-	-	-
	18	-	-	-	-	-	-
	17	-	-	-	-	-	-
	1, 8, 14	-	-	-	-	-	-

APPENDIX TABLE - Cont'd

Type and Name of Reporting Authority	Purpose(s) of Model (from Table 3)	Question 3	Question 5	Question 6	Question 7	Question 8	Question 9
Higher Education System:							
Ontario Ministry of Colleges & Universities(1)	2,4,6,8,10, 12,14,15,17,18	IBM 360/85	SRG	2 yrs.	**	4 yrs.	cont.
Council of Ontario Universities (4)	18	IBM	Own staff	2 mths.	-	4 yrs.	freq.
	4, 9	IBM	Own staff	4 mths.	-	once	once
	17	IBM	Own staff	2 mths.	-	3 yrs.	freq.
	22	IBM	Own staff	-	-	-	-
B.C. Post-Sec. Educ. Enrollment Standing Committee (1)	5	IBM 360/67	University consultants	1 year	4 mths.	1½ yrs.	twice

[1]Number of models reported

[2]Unknown, no response, not applicable.

[3]Still in design stage

[4]Still in implementation stage or continually implementing

[5]Discontinued

SAMPLE

QUESTIONNAIRE

Mathematical Models for Decision Making in Education

1. Name of institution, system or jurisdiction
2. Name or description of the model
3. Type of computer installation on which it is run
4. What is its main purpose? (e.g. to predict enrollment, to simulate payroll, to prepare individualized timetables, to make decisions on programs, etc.)
5. Who designed the model? (e.g. own research staff, consultant firm. Please give name(s)).
6. How long did the design stage take? (e.g. 6 months)
7. How long did the implementation stage take?
8. How long has it been in use?
9. How frequently have modifications been made to the original design?
10. What did its design cost? (rounded estimate of direct costs)
11. What is its annual operating costs? (rounded estimate of direct costs such as salaries of personnel, supplies and overhead)
12. If model was implemented and its use is now discontinued, why? (Give main reason)
13. If you can supply us with any further information which hasn't been covered above, or wish to make any comments, please do so below

Thank you for your co-operation