SOME COMMENTS ON THE ROLE OF

COMPUTERS IN MANAGEMENT EDUCATION

383-69

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April, 1969
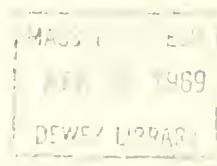
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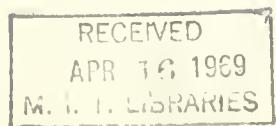
Abstract

This paper traces the development of a philosophy of computer
education at the Sloan School of Management, and attempts to isolate the
important components of this development in terms of computational
resources, student interest and faculty capabilities. Some suggestions
about the course of future developments are made.

Introduction

This paper begins with a statement of my view of the current philosophy of computer education as practiced at the Sloan School of Management. I must emphasize that this is a personal view of the present situation. The second section of the paper is concerned with the history of computer education during the 1960's at the Sloan School. This history indicates clearly the basis for our current philosophy. The paper concludes with some suggestions about the future course of development in this area of management education.

The Current Role of Computer Education

Fundamental to any philosophy of education is a view of who is being educated. At the Sloan School computer education is involved with seven distinct groups of people:

1) Prospective Managers (non-computer areas)

2) Prospective Managers (information systems responsibility)

3) Prospective Management Scientists who will use

substantial quantities of computer resources

4) Prospective Computer Professionals

5) Practicing Middle Managers

6) Practicing Senior Executives

7) Out-of-course and other students.

The interests of these groups clearly differ quite substantially from one another. One of the important assumptions of our curriculum design is that we will service the needs of groups 1, 2, 3 and 4, and recently we have been asked to adapt ourselves to groups 5 and 6 as well.

Axioms of Design

The fundamental axioms of our design are:

1) That students must be directly acquainted with computers on a machine language basis, and

2) That students must have direct access to computational resources for their own experimentation.

The first axiom, that we will use machine language as a basis, has several important consequences. First, machine language is rather precise. This means that it is possible to communicate in reasonably unambiguous terms. Second, machine language allows description at a level which is very close to the actual structure of the machine itself. At this level understanding machine language and understanding the machine itself become the same thing. This avoids terrible confusions which can arise in certain circumstances if one does not have a grasp of the real underlying principles of operation of the computer. Such misunderstandings often cause problems to be solved in an extremely inefficient fashion. Third, if we can present a common machine language to all of our students, then we improve the channels of communication within the student population itself, where a significant part of the learning process takes place. It is also possible to use such a language in several courses within a sequence, thus avoiding substantial set-up cost in all of the courses after the first. It also becomes worthwhile, with a common language, to develop a substantial "reference library" of programs and language translators which can be used by students at all levels to improve their understanding of the machine and of computation.[1]

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[1]This point is discussed in some detail in Ness, Green, Martin, and Moulton, "Computer Education in a Graduate School of Management", Sloan School of Management Working Paper 382-69; and in Moulton, G. A., "The Design of an Aid to the Teaching of Computer Technology: The STUPID System", Unpublished S.B. thesis, M.I.T., February, 1969.

The second axiom, that the students must have access to computational resources, also has important consequences. To understand the problems of computation it seems to be necessary to do battle with the hard realities of actually getting programs to work. The experience gained by actually using a computer system provides a valuable basis for insights into the system design and system utilization process. Without this practical exposure, the student is in the situation parallel to that of a language student who is learning vocabulary but not being given a chance to practice using it. Computer instructions are tools which can be used in problem solving. The student can be told how these tools perform, but it will eventually be necessary for him to use the tools if he is to understand how he can apply them to his problem.

Course work in computation is extremely important in developing the passive vocabulary which allows the student to "read" and understand programs. He is thus given the ability to extend his knowledge. This applies equally well to both machine and higher level languages. With a passive vocabulary it is possible to understand someone else's solution to a problem. This does not, unfortunately, guarantee that the student will be able to solve such problems on his own. To solve problems an active vocabulary is necessary. This active vocabulary is obtained by exercising the passive vocabulary. The student is placed in a context where he must use the knowledge he has gained to solve problems. As he does so, his ability to direct the problem solving capacity of the computer to the problems at hand increases directly with experience.

There are, of course, certain dangers inherent in teaching programming at the machine language level. Machine languages differ from one another much more than implementations of a higher level language. Thus, knowledge of the machine language level is less directly transferrable than knowledge at a higher level. Nevertheless, the model of how a computer works which is gained from an understanding of its language is, in reality, quite transferrable. Thus such knowledge is really somewhat more general than might at first be imagined.

Another danger is that teaching machine language programming will cause students to focus on problems of micro-cosmic efficiency. This is indeed a problem. It is also an opportunity to raise in very concrete terms questions of program efficiency versus effort. Some programmers worry too much about local efficiency, but this is no reason to avoid dealing with such issues, for often programming efficiency is the difference between being able to do a job, and not being able to do it at all.

Current Curriculum

These axioms find some expression in the current curriculum. The current design encompasses three courses:

1) 15.541 - Management Information Technology
2) 15.542 - Management Information Systems
3) 15.555 - Advanced Computer Systems

These three basic courses are supplemented by several offerings in areas of current faculty interest.

Course 15.541 is basic to the curriculum. It is designed to address both of the axioms set forth above. It is fundamentally a course in computer problem solving, responsible for teaching a common machine (PRISM) and for providing practical experience using that machine. The course also provides a thorough discussion of hardware from the standpoint of characteristics and costs.

Course 15.542 follows on from this to apply the technology and techniques learned in 15.541 to problems of management information systems. It is partially a case study course, where the cases establish a realistic context and the student is responsible for systems design applying the technology that he knows to the situation.

Course 15.555 follows on from 15.541 in the technological stream. In this course the student is acquainted with more advanced aspects of programming and computer hardware than the earlier course has time to cover. The emphasis here is on programming languages and computer systems structure.

The courses taught by the faculty in areas of particular interest to them usually number three to five per year. Since it is difficult for the student to count on any particular course of this kind, these courses are not viewed as a basic part of the curriculum. Some of them are taught on a regular basis, however. Courses in operations management (production) and marketing have become a regular part of the curriculum. Further,

there are regular offerings in such areas as simulation and heuristic programming. The popularity of such courses at an advanced level is additional indication of the demand for knowledge in this area.

In addition to the formal course structure, most learning about computers takes place through the research-assistant mechanism. The research assistants of the faculty members who are interested in (and active users of) computation often have substantial exposure to machines. Such learning is not usually very well structured, but is often extremely important.

It is now appropriate to consider the question of how well this program fits the needs of the student population. This will give some indication of the strengths and weaknesses of the present design, and will thus point in a direction of appropriate future development.

<u>Student Needs and the Curriculum</u>

The needs of the first group, potential managers with interests in areas other than computers, are not directly faced. To some extent these people can take 15.541, but that is really too deep a penetration for their interests. They would be better served by a survey course,[2] although few members of the present faculty would care to teach it.

The second group, potential managers of areas directly involved with information systems, find their needs quite adequately met by 15.541 and 15.542. This sequence provides a sound technical background and a

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[2]It is really more appropriate to say that these students would <u>feel</u> better served by such a course, not that they would <u>be</u> better served.

reasonable amount of experience. The material taught in 15.541 and 15.542 is not well integrated at the present time, but steps are being taken which will guarantee a much closer tie between the two courses. Some students would like to see a further course in the sequence dealing with a "real" systems design problem. This will be considered below, but I think the needs of the majority of the students are reasonably well met.

The third group, management scientists who will use substantial quantities of computation, may be subdivided into two categories: 1) researchers, and 2) problem solvers. The first of these typically find their needs met by the sequence 15.541 and 15.555. The extension of the basic course in the technological direction provides an opportunity to learn about other computer languages and other ways of structuring information. This often proves valuable when attempting to solve problems with the use of the computer. The informal method of being thrown directly into "the soup" is still used to educate this group about the realities of actually accessing computation; it may be the best way of teaching such material, although some suggest that an organized shove might be more appropriate.

The second subgroup, managerial problem solvers, are less well served. A disciplined offering of computer dependent techniques may well be appropriate here. Courses in simulation techniques, for example, are regularly given but do not form a part of a larger plan.

The potential computer professionals in the Sloan School usually take all three courses, plus one or two in the department of Electrical Engineering. It is clearly not possible at the present time to obtain a professional education in this area without substantial advanced studies (many of which should be taken outside of the Sloan School).

The fifth and sixth groups, middle managers and senior executives, have become a concern of the computer group for the first time this year. Since the regular program courses are not appropriate for these groups, new units have been designed to be incorporated into these programs. The course 15.185, Information and Decision Systems, combining efforts of operations management (5/9), industrial dynamics (2/9) and management information systems (2/9) is being offered to middle managers (Sloans) for the first time in the Fall of 1968. In a similar fashion, computer oriented material has been integrated into the management information and control course given to the Senior Executives. Quantitative methods, information and control and information systems are now taught together as "Management Decision Systems". Later in this paper I will comment on the extent to which these programs satisfy the existing needs.

The needs of out-of-course and other students are not met in any formal sense by our program. This seems appropriate because this group of students changes in number and kind depending on what courses are being offered in other parts of the Institute and depending on other factors which are beyond our control.

Failing of the Present Program

It seems that the most substantial failure of the current curriculum in both the managerial (15.541/15.542) and technological (15.541/15.555) streams of education is associated with our inability to provide sufficient resources to allow students a significant experience in the real use of machines. We have fallen prey to the "poverty cycle" with respect to computation, and it will be necessary to "prime the pump" with a reasonable quantity of resources to break this cycle.

There is no course at Sloan which has sufficient resources to allow its students substantial access to on-line computation. This means that many students never make the investment required to learn how to use such systems. This, of course, produces the effect that no course can assign such use because the setup costs would be too high (i.e., the students would spend more time fighting the computer system than learning the subject matter). The cycle is thus complete.

A second aspect of this feedback process may be seen on the faculty side. Since the resources are too expensive, the faculty does not find it profitable to develop problems and programs which might be useful in such an environment. Therefore they do not need the resources.

I am convinced that a substantial quantity of computer resources are necessary to the development of the kind of educational program which is appropriate to the Sloan School. The availability of resources seems to

stimulate interest in using them and this use seems to be a necessary step
in developing a realistic view of computation. This also suggests that
the availability of resources may be an important influence in attracting
good people. I will return to this point later.

Relation of MIC to MIS/MIT

The current curriculum is divided into management information technology
and management information systems. A related area, where activities
bear an important relation to those in information systems, is management
information and control. In the Sloan School this group has emerged out
of the functional area which was formerly known as accounting. The
interests of the faculty in this area parallel those of the people in
information technology and systems, except for the direction of their
focus.

A central concern of the information and control group is the
development of systems and procedures which improve the quality of
information that managers receive. These systems and procedures arise
out of an understanding of management's "needs" for information (i.e.,
its value). It is clear that costs enter into any practical consideration,
but the emphasis of interest for the information and control group is on
the needs for information and its values. Thus their attention is
directed to the design of effective planning and control systems.

The information systems group, on the other hand, is centrally concerned with bringing the technology to bear on the solution of management problems. The interests of these groups thus are closely related and there is no clear line dividing them, in so far as they both deal with computers in some way. Up to this time, however, it is fair to say that the computer has been a central focus of interest for the MIS group, but only a peripheral one for the MIC group.

A Bit of History

The Sloan School's direct interest in computers began with an IBM 650 computer that Sloan shared with civil engineering. By 1962 the uses had outgrown this resource and we obtained an IBM 1620. This, for reasons we will see in a moment, has proved adequate up through 1968, but by February 1969 this machine was moved out to make way for an upgraded IBM 1130.

The need for computer resources can, broadly speaking, be divided into two major areas. First, resources are necessary for education about computers and second, direct computational resources are needed to support teaching and research in areas that are not primarily computational (i.e., time series regressions of economic data and the like). In the last few years, software has been developed which allows people without substantial experience to use our computer facilities more easily. This has had the effect of increasing the utilization of the facility markedly. It is likely to expand usage even more in the near future.

While the M.I.T. Computation Center has provided large capacity resources to support teaching and research, the Sloan School has been fortunate because Project MAC came along and provided substantial quantities of computer time for educational purposes. Without Project MAC the Sloan School would have found its resources terribly inadequate to meet its educational responsibilities.

Thus the development of MAC provided three years of shelter for us. We were able to do research on computer applications which would have cost the School hundreds of thousands of dollars if they had been forced to supply the resources. We have never been forced to account for, or otherwise face up to, our consumption of resources in this dimension.

On the educational side, we have seen the curriculum within the Sloan School grow from one course for each term each year (Emery's first version of Management Information Systems) to three courses for two terms plus several one-term special projects. This represents an increase in demand for class work of about 1,000 percent in a seven year period.

With this huge increase we have seen very little expansion of the access to computer resources. This has not caused as much trouble as might have been expected because much of the effort of the faculty has been devoted to curriculum development, and thus they have not been able to devote the attention that might have been desirable to giving the students practical experience with computation. As more time is devoted

to developing appropriate homework problems, consumption of computational
resources should be expected to increase markedly. This change has
already begun with 15.541 and will soon encompass 15.555. Also, the
demand for special subjects is expanding.

The Evolving Role

It is clear that the role of computers in management education has
grown significantly in the past few years. I suggest that it will expand
even more in the future. Given the lead time required to develop the
resources that the Sloan School needs in this area, it is imperative that
the School make a direct commitment of the money and faculty talent
necessary to put the School on the frontier of development.

A natural advantage accrues to the Sloan School because of its
association with M.I.T. -- the recognition of M.I.T.'s role at the
frontiers of computer technology. People naturally expect our School of
Management to be deeply involved in and committed to expanding the role
of that technology in managerial problem solving. Computers are
obviously an extremely important part of this modern technology.

Other universities, notably the Harvard Business School, have
apparently decided that computers are here to stay. They evidence this
by their willingness to deliver a substantial quantity of computation to
their students. We are thus faced with the interesting situation that
our students, although located in an environment which is responsible for
much of the significant research in computation, may have substantially

less direct access to computer resources than do their peers at the
Business School. If this situation persists, the Sloan School will
surely lose what might otherwise be a very significant advantage.

A comparative note might be of interest. At the present time the
Harvard Business School spends approximately $68,000 (= $200/student)
on computation consumed in direct support of course work by the students.
These figures do not include any of the amounts devoted to supporting
research. On a comparable basis we would be spending about $80,000.

Aspects of Development

I see four different needs that must be considered in determining the
direction of development in management education with respect to computers.
From consideration of each of these we can establish a reasonable set of
priorities to guide the management of our existing resources.

The four aspects of the current situation that demand attention
are:

1) Development and Enforcement of Standards

2) Curriculum Development

3) Recruiting

4) Computer Resources

Standards

It is difficult to suggest how to go about the process of developing reasonable standards for performance in our area. Standards tend to evolve without being explicitly articulated. It is much simpler to suggest that reasonable standards can be enforced by the area faculty as a whole.

At the present time, for example, general examinations in our areas (MIS and Computer Sciences) are set by an examiner who is responsible for setting the entire examination. Custom dictates that he call upon his colleagues for questions, but rarely, if ever, is the faculty called upon to consider if the examination expresses a reasonable balance of overall interest in the area.

For example, in the past two years with the emergence of computer science as a common "underlying discipline", the examinations in management information systems have tended more and more to exclude questions appropriate to management information technology. This may be a perfectly appropriate development, but I suggest that it has happened by inadvertence, rather than design and this does not seem like the right way to go about establishing the standards that we need.

Curriculum Development

The needs in the area of curriculum development have been discussed before in an informal note I wrote for the consideration of the group two years ago. The needs discussed in that note persist, and other needs emerge as time passes. At the present time we must devote our attention to not less than eight general areas. The areas are:

1) A survey course, along the lines of the old 15.542, combining 15.541 and 15.542 into a one term course.

2) A Doctoral Seminar in Management Information Systems and Computer Sciences.

3) A study in systems design and implementation.

4) A course giving substantial "hands on" experience in using computers.

5) Computers and X, where X is some other functional area.

6) Tutorials in Management Information Systems and Computer Science.

7) Material appropriate for integration into the Sloan and Senior Executive Programs.

8) A course on hardware/software tradeoffs and systems evaluation.

The survey course is not, it seems to me, a pressing need. There are undoubtedly people who would prefer such a course to 15.541, but in fact I think that they are probably better educated by 15.541, and thus this need not be placed high on the priority list.

The doctoral seminar would serve two important functions. First, it would require the faculty, who are in close communication on an informal basis almost continuously, to organize and present their ideas to their

colleagues. This should prove to be a valuable discipline. Second, a doctoral seminar should give the candidates for Ph.D.'s a much better idea of the standards that exist.

To implement this idea it is only necessary to have the faculty agree to meet on a regular basis and support the seminar both by being willing to present "papers" for discussion and by their regular attendance and commitment to the discussion. If the course then works out as well as should be expected it could be offered for credit in later years.

A field study course has been requested by many students. They feel that 15.541/15.542 is a valuable sequence, but that some substantial amount of on-site experience would prove extremely valuable.[3] I think that students are likely to over-estimate the potential value of such a course, however, and thus I do not place it high on the list of priorities. This should not be interpreted as suggesting that problem solving experience is not vital -- it is. I am only saying that on-site experience is not as valuable as some people tend to think.

A course giving the student some substantial "hands-on" experience with computation would be an important addition to the technological sequence. Again, many students who might be interested in such a course do have access to computation in other ways (as research assistants, for example), but some organized education in this area may prove to be

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[3]15.542 offers some on-site experience already.

extremely important to the development of the kind of students that we need. Such a course might also prove to be a valuable way of developing programs and systems which could be used by the students and faculty in all functional areas. It would thus not only teach systems design, but the systems that are designed could apply directly to basic problems in other areas.

This is perhaps an appropriate place to differentiate between the value of on-site systems design experience and hands-on computer experience. I suggest that the richness of a real environment is necessary for learning significant things about computers, but unnecessary with respect to systems design, simply because the qualitative characteristics of the computer environment persist from one location to another while those of the problem environments change rather significantly. Thus hands-on computer experience is transferrable in a way that is not characteristic of systems design experience.

The idea of "Computers and X" has been experimented with in a small way by Zannetos and myself in our 15.512, Advanced Concepts in Managerial Information for Planning and Control. I think it is fair to say that this was successful enough to suggest that similar developments in other functional areas may prove worthwhile. I suggest that this area is particularly important because it is here that we might most reasonably expect that the Sloan School could carve out for itself a truly unique role in management education.

Tutorials (special studies) in computer sciences and management information systems have been offered on a regular basis by members of the faculty. All too often these tutorials have simply been used in an attempt to prepare for general examinations. This should not be their purpose. Such tutorials should be reserved for responsible professional development at an advanced level. They should thus supplement rather than supplant the material given in the normal course sequence. Such tutorials should lead to research papers of substance, and should be included in the doctoral seminar on a regular basis. Those tutorials are a mechanism for providing for quality education in an environment which must produce both quality and quantity.

As mentioned above, we have recently been asked to prepare material for incorporation into the Senior Executive and Sloan programs. We have used this as an opportunity to test the feasibility of joint (cross-functional) efforts in such areas by creating a course called "Management Decision Systems", drawing heavily on Quantitative Methods, Management Information and Control and Management Information Systems. Early results indicate that this approach may prove very fruitful, particularly given the severe time constraints which characterize these programs.[4]

Finally, it is important that we begin to develop course material directed to the problems of systems evaluation and hardware/software tradeoffs. Many of our students who become practicing managers will have

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[4]This section differs substantially from the earlier version of this paper.

to make decisions in this area, and a body of knowledge which will aid in this process is beginning to emerge.

This gives some indication, then, of the magnitude of the curriculum development task which faces the faculty in our area. Notice that the above discussion does not contain any provision for all of the courses in advanced special topics which must also be developed. It is simply a discussion of the basic "core" of material which must be offered to our students if we are going to give them the opportunity that we should.

I hope this makes clear the necessity of a substantial investment in curriculum development in this area. Most of the functional areas of management studies are fortunate enough to have a substantial existing corpus of material to teach, and progress can be decently evolutionary. In management information systems and computer sciences virtually all of the courses have been developed by the present faculty, and the situation is revolutionary. Thus it is absolutely vital that our group be given command of sufficient resources to allow responsible development of this material.

Recruiting

It would appear that some effort to recruit capable students in these areas will prove to be increasingly important. Many schools are anxiously awaiting the production of some volume of output by the Sloan School. The large, and ever growing, support for our present program amongst the Master's candidates is not paralleled by corresponding admissions to the

Doctoral Program. Whether this is by inadvertence or neglect is not important here. What is important is that we begin to recruit people who are appropriate students for the kind of program outlined above.

It should also be noted that the availability of computer resources may prove to be a very attractive element which can be capitalized on in the recruiting process. The kind of students that we need may well be very responsive to the availability of such resources.

Computer Resources

I will turn now to an issue of great importance, the availability of computer resources. As suggested early in this paper, we have only begun to see the demand for computation which will emerge in the not very distant future.

We are just beginning to do research into computer-assisted instruction. This research will consume a substantial amount of effort and some computational resource. Should it prove successful, we will need even more computational power than we presently envision.

We need to invest further effort into bringing the computer into some of the non-computer courses. The manager of the future, regardless of his specific role in the organization, will have cause for regular and frequent access to computational devices of many varieties. We do not live up to our responsibility with respect to the education of our students if we do not provide appropriate experience in this regard.

For a moment let us recall our original axioms of design. I have suggested that our students need substantial access to machines on a regular basis. Computational support is a necessary component of the basic curriculum. 15.541 demands a substantial amount of computer time to provide such access. More advanced courses, such as 15.555, have not used very much time in the past, but as such courses are integrated into a meaningful curriculum it is probable that they will consume more and more resources.

Students and faculty also need to have a wide variety of terminal devices available. At the present time it is not possible to teach a course at Sloan which would allow the students to use the facilities of M.I.T.'s time-sharing systems simply because there are so few terminals available. This means that students cannot easily access many of the languages which are available only through these systems.

It should also be noted that the availability of terminal devices for both classwork and research has an important side effect in establishing an environment where such facilities are regarded as useful in every day activity. This clearly provides a basis for obtaining an intuitive sense of the usefulness and applicability of such devices, and it serves as an important creative stimulus as well.