Social Needs in Secondary Mathematics Education*

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Mathematics education and computer education

It is an amazing fact that today we are concerned about a question which 20 years ago nobody would have thought of.† On the contrary, more and better mathematics for all students and all grades was the paramount goal at that time; and that students would need it, and that society would need it, was beyond any doubt. Today we are startled that many people no longer seem willing to take that goal for granted, and we are aware of our own uneasiness in the matter. But the menace behind it all, which actually makes the question acute, is the growth of computer technology and its penetration into the schools. Many seemingly unrefutable justifications for school mathematics now look weak and much less convincing. In the USA computer education has partly replaced secondary mathematics and continues to expand. In several European countries informatics has been or is being established in the curriculum as a competitor to mathematics.

It is not necessary to recall the significance of computer technology in any detail here; I content myself with quoting a few sentences by M.F. Atiyah.

> "It is now commonly acknowledged that we are firmly embarked on an economic and social revolution, which will be comparable in scope and effect to the industrial revolution .... Whereas the industrial revolution is usually measured in centuries, the computer revolution is properly measured in decades." [Atiyah 1986, p. 43] .... "As we all know, the present economic scene is of a widespread decline of traditional industrial and simultaneous growth of computer related industries. This is the economic side of the revolution. Naturally, this means that the best employment opportunities are linked to computers and this is altering the attitudes and expectations of all the younger generation. In schools and universities traditional studies are having to compete with the excitement and attraction of the computer, but mathematics, as the closest of the older discipline is inevitably in the front line." [Atiyah 1986, p. 49]

It is obvious, then, that we cannot deal with secondary school mathematics without considering the impact and role of computer technology for, and in, and beside mathematics education. This has been done extensively and does not need to be repeated here. A point, however, to which I would like to draw some attention, is the relation of both computer education and mathematics education to the field of "social needs" demands. By "social needs" demands I understand here the pressures urging school mathematics to comply with the needs for certain skills and abilities required in social practice. Mathematics education should qualify the students in mathematical skills and abiities so that they can apply mathematics appropriately and correctly in the concrete problem situations they may encounter in their lives and work. Conversely, social usefulness has been the strongest argument in favour of mathematics as a school discipline, and the prerequisite to assigning mathematics a highly selective function in the school system.

There can be no doubt that the advocates of computer education draw very much upon this same argumentation about social needs. Firstly, they deny a general need for mathematics in the social reality of the near future, since for the vast majority computers will do all the mathematics; instead, working with computers will become a paramount social need. And secondly, they hold that the computer is the better pedagogical instrument for learning mathematics applications by fostering a concentration on the problem solving process instead of on rote computing, and in allowing much more realistic problems and realistic approaches to problems to be introduced in school.

I do not ignore that the social needs aspect is not the only argument in favour of computer education in school. As with school mathematics, computer education is not only advocated from outside school, but also from inside, by teachers and mathematics educators. A compilation of pedagogical arguments is given by Dörfler and McLone.

> "Computer education (in a ... broad sense) meets almost all the general objectives and goals of mathematics education. But computer education adds to these other and more relevant objectives which will certainly be of use in adult life. To solve typical problems of computer science, logical thinking, precise use of language, abstraction, formal operation, symbolization and other intellectual behaviours usually associated predominantly with mathematics are needed, and these will also be developed in computer education. Therefore one can find, if not in an outspoken form but as a tacit assumption, that learning

† The theme of the CIEAEM conference was: "Mathematics for those between 14 and 17. Do they really need it?"

mathematics could be replaced by learning to use computers. A further argument for this is that computer education could be closer to the life and experience of most students thus enhancing their motivation and interest." [Dörfler and McLone 1985, p. 80]

The quotation shows that the revival of "mental discipline" arguments is quite suitable for the support of computer education, too. Moreover there are those somewhat hedonistic mathematics teachers (rather frequent among secondary II mathematics teachers in Germany, for example) who are enthusiastic about the computer because of its new possibilities for mathematics instruction. And we should also keep in mind the fascination computers have for many students, a phenomenon of great psychological interest, which certainly counts—although it seems not absolutely clear at present, for what.

Whatever the impact of these arguments may be, in my view they are largely surplus justifications: the central argument in favour of computer education is an avalanche-like growth of computer technology in social reality, and hence the usefulness of computer education: the use of computers in social reality making the need for mathematics in that domain obsolete to a very large extent, and the use of computers in schools reconnecting them to social practice.

If we actually agree that so far both mathematics education and computer education have mainly been legitimated by social needs and usefulness respectively, the relationship of needs to their respective responses has consequently to be our central point of examination. How has this relationship so far been conceived? Do we agree with the correlation models traditionally employed? Are there differences with respect to their specific validity for mathematics education and for computer education?

It is my contention here

- that the traditional understanding of how mathematics education can, and must, comply with social needs by means of mathematics applications is essentially deficient;
- that this wrong understanding is a major cause of a distortion in mathematics education and of the failure of mathematics education to comply with social needs;
- that computer education is superior to mathematics education if we try to deal with the application problem on the basis of this wrong understanding;
- that an indispensable safeguard for mathematics education is a new understanding of the relations between social needs and mathematics education.

Social needs

We should first try to get a clearer notion of the deficiencies of the traditional conception of how school mathematics complies, or should comply, with social needs. The traditional position has nowhere been given sharper outlines than in the high school debate in the USA, so it may be useful to draw on the American example for illustration.

Around 1912 "social needs" became a concept of paramount importance in American education. At that time a heroicizing view of the businessman, positivism, and social darwinism, combined to produce an utilitarian ideology of rare blatancy. Its catchword was "efficiency"; a "cult of efficiency" pervaded all areas of social life, including the school system. The ideology of efficiency is both strengthened and instrumentalized by three very consequential achievements: F. Taylor's "scientific management", Thorndike's behavioristic learning theory, and the development of standardized tests.

The desolate state of the schools, severe criticism, and a call for efficiency in this area, make the school system susceptible to a breach by the new ideology; the more so as in a very immediate way it is exposed to such trends by its very construction: local autonomy, administration by a superintendent who depends directly on a local, mostly lay, school board.

To adapt the principle of efficiency to the educational system means to subject the school to the logic of economics. F. Bobbitt, a school administrator and head of the movement, first applied the basic law of scientific management to the organizational parts of the school administration. But a systematic application of scientific management demanded the extension of its principles to all areas of the school system, including the curriculum of every single school subject, and sweeping away pedagogical traditions and those of the didactic disciplines. For it is a prerequisite of the application of scientific management that the starting point as well as the final state of production be clearly defined. Viewing the school by analogy to a factory/plant, the student is the raw material, the adult the end product, the teacher is the worker, and the curriculum is everything that brings about the change from raw material to end product. The curriculum is conceived as a series of stimulus-response acts accompanied by continuous testing.

Since society is the customer of the factory "school", the society decides what the product it buys should look like. "A school system can no more find standards of performance within itself than a steel plant can find the proper height or weight per yard for steel rails from the activities within the plant." [Bobbit, 1913, p. 34]

Curriculum development, then, is viewed as follows:

> "The central theory is simple. Human life, however varied, consists in the performance of specific activities. Education that prepares for life is one that prepares definitely and adequately for these specific activities. However numerous and diverse they may be for any social class, they can be discovered. This requires only that one go out into the world of affairs and discover the particulars of which these affairs consist. These will show the abilities, attitudes, habits, appreciations and forms of knowledge than men need. These will be the objectives of the curriculum." [Bobbitt, 1913, p. 42]

And more concretely:

> "... the commercial world can best say what it needs in the case of its stenographers and accountants. A machine shop can best say what is needed in the workers that come to it. The plumbing trade contains

the men who are the best able to state the needs of those entering upon plumbing; and so on through the entire list." [Bobbitt, 1913, p. 36]

The society here is, above all, the employer, and the social needs are skills of very limited complexity. This conception of the content of the curriculum corresponds perfectly to the behavioristic method of instruction and the testing practice. It is an essential assumption of this conception, with regard to both subject matter and method, that all that exists, exists in measurable quantities. Callahan reports: "Could standards be established and scales be developed in areas such as history and literature, where some of the expected outcomes involved social and moral attitudes, judgement, and appreciation? Bobbitt took the view that this would be difficult but it could be done 'for every desirable educational product whether tangible or intangible'. It might take some time, and much preliminary work would have to be done, but, he said, 'After our profession has scaled the lower heights, it will be time enough to prepare to scale the higher.' " [Callahan, 1962, p. 84]

Bobbitt abstained from developing concrete curricula, thus leaving much work to his disciples: "... to secure an objective basis for a complete reorganization we must carry through an analysis of life activities. The absence of such an analysis undermines the validity of any comparisons between what the curriculum is and what it ought to be." [Charters, 1923, p. 151]

And the efforts eventually undertaken really aimed at comprehensiveness: "(Charters) developed a curriculum particularly for women as part of the famous study he conducted for Stephens College in Columbia, Missouri. Charters' task was to develop a program which would provide 'specific training for the specific job of being a woman'." [Kliebard, 1975, p. 60]

We can hardly believe that all this was taken seriously for a time, and I felt I had to give some illustrative details in order to evoke the circumstances. But my interest here is not the absurdity itself; I rather wish to show that these were the circumstances under which the blessings of behavioristic instruction and standardized tests came to us, and under which social needs became a focus of curriculum theory.

The trend to replace the efficiency movement from about 1926 came from Progressivism. Although sharply contrary in their theories to the advocates of efficiency, the progressivists shrank from breaking radically with them. They disregarded the behavioristic instruction, but accepted standardized testing; the concept of social needs played an important role in their theory as well, although with another emphasis, stressing the social instead of the needs aspect.

Thus the achievements of the efficiency period survived. During and after World War II, when in turn progressivism had become discredited and the absurdities of efficiency forgotten, they reverted to a new respectability, more refined in their technical aspects and much more cultivated in their appearance.

After the War curriculum theorists such as Tyler, Goodlad, and Taba, relied on Bobbitt's scheme of making social needs the objectives of curriculum determination, with a major concern in the compilation and classification of basically obscure, additive curriculum material. Later on, together with many other reform ideas, this principle was adopted by curriculum reformers outside the USA, who ignored the origins of this approach. It was applied in the national Swedish IMU-project, which was based on demand inquiries in industry, trades, administration, etc. In Germany educational researchers as S.B. Robinsohn set out from this approach; and ultimately even preparatory research studies for the Cockroft report [ACACE 1982, Sewell 1980] relied on demand analysis in order to deduce curriculum objectives.

The behavioristic method of instruction and standardized testing have been even more influential. In the USA and many other countries standardized tests have become a kind of natural appendage of pedagogy. For its integrated control facilities, behavioristic instruction has always remained a favourite of the administration in the USA, thus it became the greatest impediment for innovation in the recent reform period. Outside the USA behavioristic instruction has been less acknowledged; nonetheless the behavioristic example has fostered tendencies of increasing regimentation. In Germany, e.g., in the late 70s syllabuses were formulated in terms of behavioristic objectives.

Social needs as the subject matter of the curriculum is thus complemented by social control. Both deserve further examination here; I shall first look at social needs as curriculum objectives.

Mathematics applications

In Bobbitt's view of the curriculum, the individual, concrete, need identified in social practice is declared to be an objective of learning and directly incorporated in the curriculum. The limitations of this approach are well-known and must not be repeated here. The basic dilemma of the approach is generalization: the generalization of the learned correlation between problem and solving pattern is indispensable because of the tremendous variety of phenomena in social reality, and because of the variability of single, otherwise identical, phenomena. Generalization, however, is virtually impossible without risking destroying the bond between problem and solving pattern. As far as the behavioristic approach to mathematics applications—or the traditional skill-oriented applied mathematics instruction, mainly social arithmetic—have dealt with this dilemma, a solution is expected from a sufficient comprehensiveness in both the solving patterns, or rules, and the concrete objects, the latter often being secured by a great variety of tasks.

In other approaches to applied mathematics, including traditional ones in "higher" education, it is recognized that the problem of generalization is rather to be solved by implanting generalization as an ability in the student. This ability is expected to result from re-connecting the solving pattern to its mathematical background. The student is to be enabled to *understand* the solving pattern and hence to apply it appropriately.

Unfortunately this conception has never really worked satisfactorily. The students' difficulties with applications are notorious. The growing despair of children faced with a cyclist riding from A to B, and a motorcyclist riding from B to A, and without the slightest idea where to imagine a meeting-point C—such is a fundamental school experience of many who are not lucky enough to have developed a particular affection for mathematics in their early years. And often there is no change in the students' later life. The Cockcroft report [Cockcroft, 1982] confirms what we know from daily experience: if not professionally concerned with mathematical applications, adults tend to avoid other than the most primitive applications whenever they can.

One—or maybe the major—reason for students' difficulties with mathematics applications in my view is the following: in the relation mathematics/problem solving model/reality, very much sophisticated investigation has been devoted to one part, the relationship of mathematics to the problem solving model, but very little to their relations to reality. We are commonly not aware that the intricacy in the relationship of mathematics application and reality may also, partly, be rooted in the structures of reality.

Regular structures in reality, which are accessible to mathematical analysis, may originate from two causes: from regularities based on laws of nature, and from the organizing interference of man, who in the course of history again and again spreads networks of organizing structures over almost every area of nature and social life. The explication of the former is descriptive, however, mostly connected to an instrumental interest in manipulating nature; the latter is instrumental from the very beginning.

It is important now that we do not normally perceive these structures as an artful edifice but as fragmentary traces and patterns of them, which, combined with numerous subsequent structuring processes, may have become cultural techniques, instruments, or tools, in our daily life. This makes it difficult to understand them, the more so as there are two crucial implications. First, these instruments were often constructed in order to replace an explicit use of mathematics where it had formerly been required, and consequently it is not easy to discover the mathematics *behind* the instrument. Secondly, however obsolete the original intentions of the construction of an instrument or a problem solving device may be, they are still effective: an instrument may underlie changes of application, but it can only be used in a correct *and* meaningful way, if the principles of its original construction are taken into account.

On other occasions I have dealt with the peculiarities of the fields of reality to which mathematics is applied (I call it the fore-stage of mathematics) in more detail than I can do here. My point actually is to give an idea of the intricate nature of mathematical structures in reality in order to demonstrate more convincingly that the process of mathematics application, and hence mathematics application as a subject of mathematics education, cannot be a very simple one

In Figure 1 I give a schematic diagram of how mathematics application may be conceived from the skill-oriented point of view of either behaviorist instruction or our traditional applied arithmetic.

The diagram shows that the problem solving process does not practically pertain to mathematical knowledge and knowledge about reality; it neither requires them nor enriches them. This model is neutral with respect to learning by application, except for a reinforcement of job-experience and skills. Potential difficulties mainly lie in the correlation between problem type and type of solving pattern

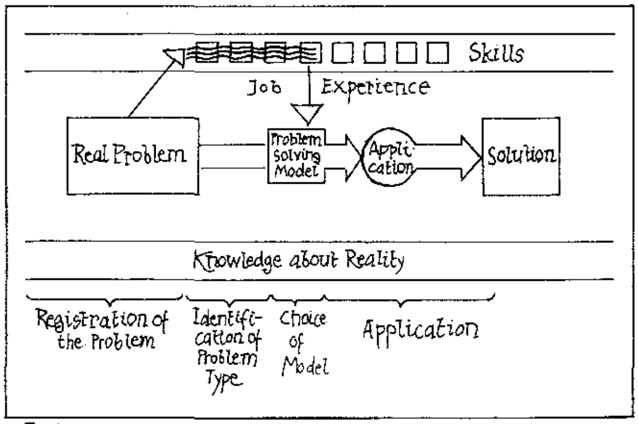

Fig 1

Figure 2 is comparatively more complicated. In this diagram I have tried to show the various activities involved in a problem-solving process which is not curtailed with respect to levels of understanding. (It goes without saying that even this scheme is a terrible simplification and but one constellation among others.)

We may state that the preparatory stages are actually the most important in the whole process with respect to the involvement of both cognitive activities and learning potential. And the application does not end with the establishment of a solution, but comprises its transfer to the level of concrete significance, and moreover an integration of the outcome with the levels of mathematics and reality understanding.

Needs institutionalized

So far we have dealt with social needs mainly as a subject matter in the curriculum. It may rightly be objected that, in general, although varying according to school types and countries, the role of "social mathematics" becomes less important in the higher grades, in particular at the secondary II level. In going up the grades, emphasis in mathematics education increasingly shifts to formal mathematics. Applications, mostly taken from the natural sciences, primarily serve to visualize mathematics. School mathematics appears here as a domain of its own, detached from both reality and scholarly mathematics

This detachment, however, with respect to scholarly mathematics, is not so much due to the higher level of the

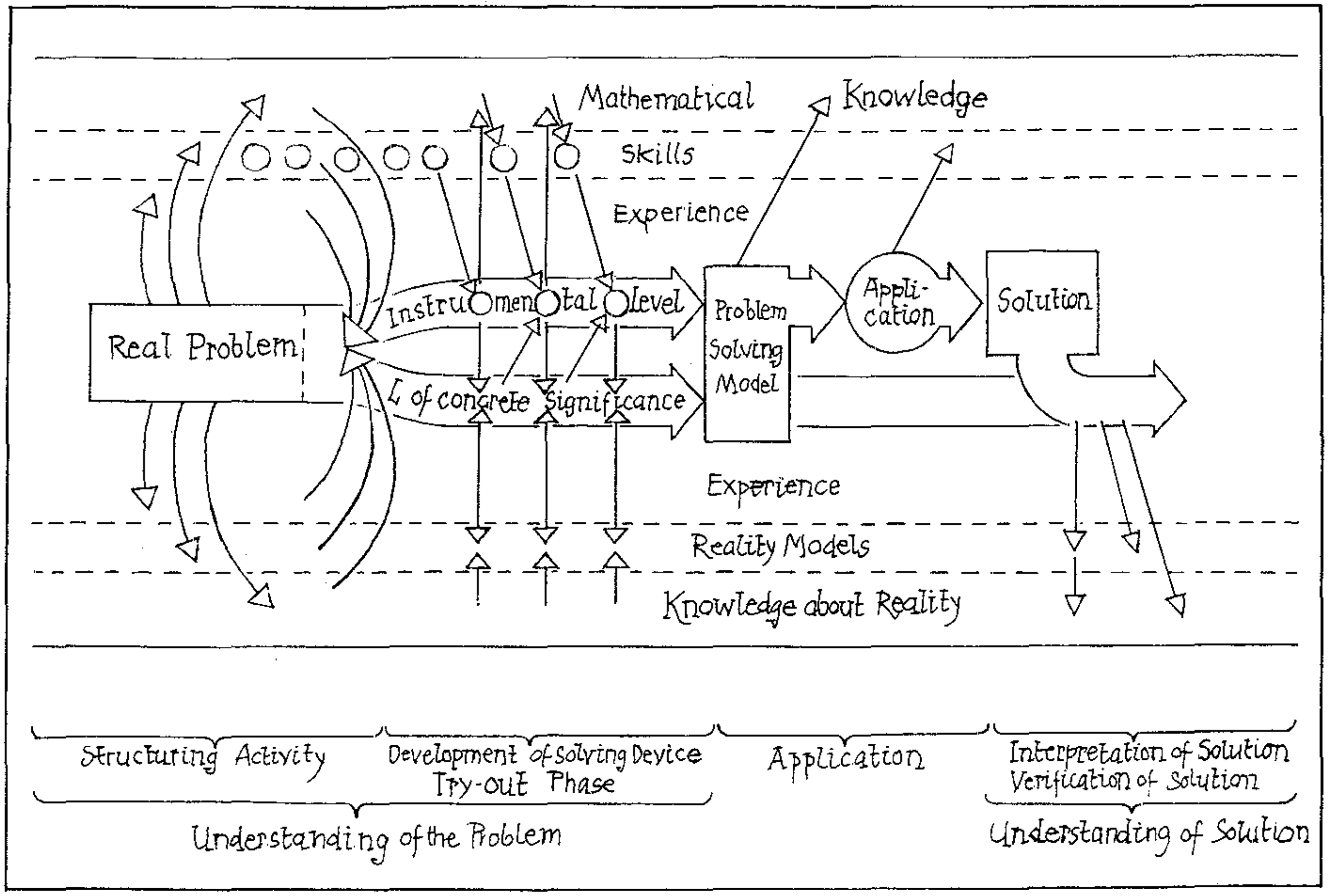

Fig. 2

latter: a gradual difference would not necessarily be fundamentally distinctive. It is much more a result of a specific school characteristic of mathematics education, namely, its orientation towards tests and examinations. Dörfler and McLone write: "In particular the influence of examinations in the later secondary years dominates both the teaching and the appreciation of what is mathematics to such an extent that other approaches in earlier years are almost totally obliterated. It this is compounded with a view of mathematics by the teacher which does not go beyond the bounds of the immediate task, a very restricted and unimaginative form of teaching is likely to result." [Dörfler and McLone, 1986, p. 91] A good survey of the constraints caused by examinations is also given by Howson and Mellin-Olsen [1986].

If on the secondary level mathematics education is more and more freed of an all too simplistic conception of social needs, this freedom is in the same proportion nullified by the more and more oppressive strain of examinations. Social needs as a subject of mathematics education is consequently replaced by social control; they are complementary.

The distorting influence of tests and examinations is effective in three ways:

— they determine the subjects of the curriculum, and to secure mathematics education is by no means the only criterion for this determination;
— they require the compartmentalization and organization of mathematical activity according to examinable units, i.e. tasks, which is fundamentally contrary to mathematical thinking. This process is carried to an extreme in the operationalization of a subject in terms of behavioristic objectives, but it is also characteristic of traditional task methodology;
— they focus interest on results, not on the process of learning and understanding.

The last point is probably the most serious one with respect to its outcome for mathematics learning. For if the only thing that counts is a correct answer obtained in a certain amount of time, activities as sketched in Figure 2, or in analogous organizations of the learning process, are inefficient and even futile. How can a teacher defend dwelling on ingenious though wrong tracks and on enlightening errors if the right attitude towards mathematics is the wrong one towards examinations?

Alternatives

Viewing the role of social needs in and social control of our present day mathematics education, and confronting it with what we could imagine to be meaningful mathematics education, it is obvious in my opinion that these conceptions are so profoundly contrary to each other that any attempt at reconciling them would inevitably result in obstructing the success of either conception. Indeed I would suggest we ought to consider how far this basic dichotomy in our school mathematics might be the source of many traditional difficulties and failures, which we persistently try to overcome, and which obstinately remain. Isn't it this schizophrenia which makes us tell the student that everybody has a good chance to learn mathematics, knowing at the same time that examinations by their very construction have to ensure a certain percentage of failures? Isn't it schizophrenia that we invite them to do creative mathematics and yet let them work for examinations? I think that children who suffer from school mathematics are not really suffering from mathematics but from this schizophrenia, which affects them quite considerably.

Keeping this in mind, let us turn back to the competitive relation of mathematics education and computer education. It is astonishing to realize that, quite differently from the case of mathematics education, there seems to be a particular affinity of computer education for what we may call the social needs and control approach. If we look back to our diagrams once again, we may note that in our complex model (Figure 2) all the more important processes which pertain to *understanding* cannot be done by a computer (although the computer may be used there in a subordinate function): the processes of structuring the problem context, of explicating an instrumental level of treatment, of translating to and fro between different levels of formal explicitness until eventually a problem solving model develops; and again the interpretation of the solution at the level of concrete significance, and the feedback to the levels of mathematical and reality understanding—in none of this can the computer replace the applier's brains.

On the contrary, in our model of skill-oriented application, where understanding is of no or less importance, the whole process, except for the identification of the problem type, can be carried out by the computer. And if we may imagine that in a restricted field of application the problem-solving pattern could be chosen by the computer as well, the application shrinks to the simplest stimulus-response bond: one has but to push the button. This then requires neither mathematics nor informatics—except for the computer specialist, who needs both.

May I add here—though this is actually another topic—that the computer need not only be employed for reductive purposes. We could as well imagine placing the computer in the center of a problem-structuring process as an agile turntable allowing speedy reflections between formal mathematics and concrete reality. This would aim at processes of learning and understanding similar to those viewed in our complex application diagram. But it could not do with less mathematics or reality understanding. In addition it might enrich the try-out options considerably. This is not a model of computer education, but of integrated mathematics education and computer education, and could moreover integrate mathematics education with other disciplines such as geography, economics, biology, social sciences, etc., as well.

The affinity between computer education and a traditional needs-and-control approach, contrasted with the problems mathematics education proves to have in this domain notwithstanding all reform efforts, has of course attracted the attention of those representatives of society who wish to keep the school on the tight rein of their demands, and of those within school who take it as the highest aim of education to comply with these demands. And in fact we register that the interest, and trust, of the advocates of what they call usefulness are rapidly shifting towards computer education. And that certainly frightens many of us. What can we infer from our previous findings as perspectives on this situation?

As my conclusion I shall try a few answers, which are, however, very tentative and maybe partly utopian. They do not pretend to certainty.

The disease of mathematics education in my view is the inert dichotomy between a direct needs obligation and the claims of cognitive development. If mathematics education keeps as it is, we shall continue not achieving our goals with respect to cognitive development, and the instruction for usefulness will be inferior to that offered by computer education. As a consequence, mathematics education will lose its place in the core of the curriculum. We shall come generally to a situation similar to that in England now at the secondary level: a sophisticated, highly demanding mathematics course for those who continue their studies, and next to nothing for the rest. One could imagine a free mathematics course alongside the other one. It is a seductive idea, but clearly, in practice it would not stand up to the selective course, and would rapidly degenerate into inferiority.

The only alternative for mathematics education, then, as far as I can see, is to settle the old dichotomy between social and cognitive demands. First we shall have to clarify our relationship to social needs. The opportunity is good: for the first time the grip of social demands, shifting to computer education, is loosening on mathematics education. Secondly we shall have to clarify our relation to computer education in the sense of a division of labor. The result should be that mathematics education will not be predominantly responsible for a direct response to social needs. Thirdly we have to strive for other examinations, which do not force us into the wrong direction. Our direction is indirect, mediate, usefulness. It is the same kind of usefulness as that to which vernacular literature education is committed: at the secondary level, other than in spelling, grammar and orthography, nobody would claim to control learning achievements by the type of examination tasks we have in mathematics. If we manage to attain a position similar to that which vernacular literature education at the secondary level has today, we may have overcome our present crisis.