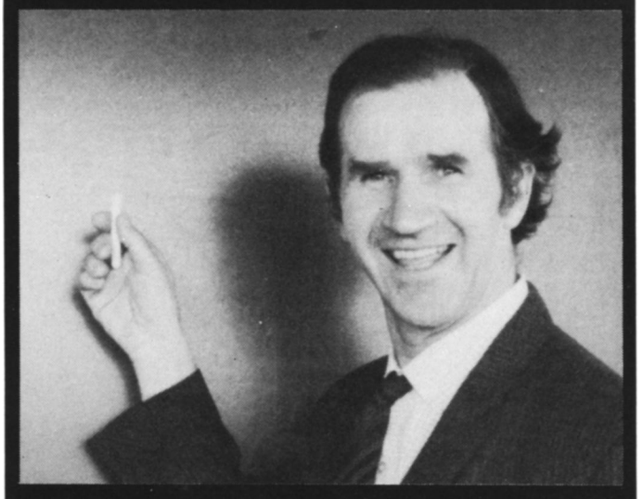
Professor Richard Skemp



The first of a series of occasional interviews with influential figures in mathematical education

INTERVIEW BY MICHAEL WORBOYS

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MW. Professor Skemp, for the benefit of those who have not read your book, *The Psychology of Learning Mathematics*,[1] may I begin by asking you to briefly outline your theory of schematic learning?

RRS. I went straight from a mathematics degree to teaching mathematics in a school. It slowly dawned on me that although I had quite a good knowledge of mathematics and was teaching reasonably bright, well-motivated boys, there were some who however hard they tried couldn't seem to understand it, and however hard I tried, my explanations didn't seem to help them. I then got interested in the psychological aspects of education and the more I thought about it, the more I realised that the teaching of mathematics depends on a knowledge of the psychological processes involved in learning it. My book concentrates on the kinds of learning which are most important for the learning of mathematics, namely intelligent learning as distinct from rote learning, although some of this is necessary as well.

Where pupils often fall down is that because they cannot understand, they have to learn by heart because that is all that they are left with. If one can discover how to present the material so that if kids want to, they can understand it, I think this is half the battle. What the book does is firstly to look at the processes of mathematical concept formation and the implications for teaching mathematics. Next, one gets these concepts linked together to form conceptual structures, called schemas, and these have properties beyond the properties of the individual concepts. To give an analogy, if I gave you a number of condensers, transistors, variable resistors, etc. and then showed you a special way of connecting these together, then the whole would take on new properties which you would never have guessed. You might find that you could receive BBC 1! The functions of symbols are enormously important in both of these processes and I look at them at some length. I then distinguish between the intuitive and reflective modes of using one's intelligence. The pupil can get along pretty well intuitively, certainly at the elementary stage. The teacher must always be able to reflect upon his knowledge to see how the concepts are interconnected. Finally, I look at the motivational and emotional factors involved. I think that this is the most incomplete part of the book and this is where a lot of my work has been done since.

MW. In your book you stress a duality in the functioning of intelligence. You describe the two modes as sensori-motor and reflective intelligence. Intelligence means more to you than just the ability to pass intelligence tests.

RRS. Yes, it does. Over the last three years, I have been discovering just how much more. One of the pieces of good luck to have come my way is that, using hindsight, if as a psychologist I had wanted to study the workings of human intelligence, I couldn't have chosen a better area of research than that of mathematics. It is a very concentrated and low-noise mode of functioning of intelligence. Using this as a jumping-off ground, I have been developing my ideas of the nature and function of intelligence way beyond the orthodox psychometric approach. This is what my next book will be about. It won't be about mathematics.

MW. Will it be relevant to the teaching of mathematics?

RRS. Certainly. I hope that it will be read by all teachers, and indeed by the intelligent general public who read books like *The Naked Ape* and *Zen and the Art of Motorcycle Maintenance.* I have found both of these books most absorbing.

MW. Returning to intelligence tests, do you think that the use that intelligence tests have been put to for the purposes of selection is a good use?

RRS. This is basically asking whether you think that selection itself is a good idea. If you do, then I think that intelligence tests are probably one of the fairer ways of doing it. They are not reliable for borderline cases and they do not tell one anything about motivation. Clearly a moderately intelligent person who very much wants to learn something will do much better than somebody highly intelligent but not interested.

MW. How have your ideas developed since writing *The Psychology of Learning Mathematics*?

RRS. In two ways. One is a continuation of the ideas of schematic learning, examining the kinds of connections within schemas in the hope of answering such questions as "What are the properties that make schemas good schemas?". Also, I went in what looked like a new direction, but turned out to be what the original thing was about all the time though I hadn't spotted it.

All my teaching experience has been with children and students who were well motivated, and rather belatedly it came to me what an enormous omission it was to take motivation for granted. Admittedly, when mathematics was taught schematically, it did seem much easier to get the children interested, but in general the problem of motivation for learning seemed such a basic one that I was ashamed of myself for having neglected it for so long. So I made a start on it, and I've been working on it now for about four years.

The result has been to relate the cognitive and orectic (which combines both the motivational and emotional aspects of learning) and I have now seen how these can be fitted together into a new theoretical model which I am getting very enthusiastic about. I have first developed it in the context of intelligence. Out of this, as a very important special case, arises quite a new approach to the learning of mathematics. I will be offering this new model for the learning of mathematics

for the first time at the beginning of April to a conference of ILEA teachers at a residential weekend.

MW. The creative use of symbols seems at the very heart of mathematical thinking. Wilder[3] cites many historical examples of how mathematics stagnated due to the lack of the necessary symbolism and leapt forward when the symbols were developed. Do you think that we give sufficient thought to the use of symbols in mathematics teaching?

RRS. I think that there is a wide open field here. Symbols are such vital tools in all abstract thinking and yet we give little thought to the tools themselves. We reach for the nearest one, instead of carefully designing tools which do a particular job best. For example, the notation dy/dx is not a good notation, as is widely agreed. On the other hand, one can quote examples where one's thinking is supported and even taken a step further by a good notation.

MW. Much research has been carried out by psychologists into human learning. What specific contributions do you feel that this can make to the learning of mathematics?

RRS. Surprisingly little I'm afraid. Indeed surprisingly little to education in general. This is partly because a lot of learning theories produced by psychologists have their origins in ideas developed with subhuman species. The work of the cognitive psychologists such as Gagné, Ausubel and above all Bruner has, in my opinion, considerable potential application in the long term.

MW. How do you see your own work relating to that of Piaget?

RRS. This is a difficult question to answer. I don't entirely know, because to know the answer I would have really to understand Piaget which I don't entirely feel that I do. I have a great respect for his work. Certainly a number of lines of thinking have been triggered off by the effort to understand Piaget which might not have been triggered off otherwise. May I also say that I have the greatest admiration for his really beautiful experiments. What I often find difficult to follow is the theoretical model which he develops from his experiments. I think that my feelings towards Piaget are very well stated by Bruner.

> "...Like others who have followed his lead, we too are in his debt, though in the end we have been led into other paths and, on some crucial points have been forced to bring his theoretical account into serious question."

MW. Relating your work directly to the teaching and learning of mathematics in schools. In your opinion, how successful are the more widely used projects in leading children to see the structure of mathematical ideas? I'm thinking particularly of *S.M.P., Nuffield Mathematics* and Fletcher's *Mathematics for Schools.*

RRS. It is some time since I had a close look at Fletcher's series of books, but when I did I liked them very well and if I had been producing material for primary schools ten years ago, I would have been very happy to have produced anything of that quality. As for Nuffield, I do not feel that I have spent enough time in a school using the Nuffield approach to give the kind of in-depth answer that the question deserves. So far as S.M.P. is concerned, I think that their greatest success lies in their publicity and organization.

MW. If you were a head of department in a secondary school and had to choose a set of textbooks for use throughout the school, which set would you use?

RRS. If I was head of department in one of the dying race of grammar schools, I should choose my own,[2] supplemented with additional examples. In a comprehensive school, I would choose the books produced by the Scottish Mathematics Group.

MW. What do you think should be the content of a secondary school mathematics syllabus?

RRS. Well, I am beginning to have a lot of sympathy with the notion of a core syllabus of basic mathematics which everybody should try to master, plus extra mathematics for those who wanted to do it and were capable of doing it. The level of mathematics needed by the vast majority of people, either in their daily lives or in their jobs, is quite elementary: but they need to understand it. On the other hand, the number of high-powered, advanced mathematicians that the world needs is relatively small.

What is most needed is relational understanding (how to put them sensibly to work) of the numerical processes that a calculator can now do much better than we can, and certainly enough competence at doing simple calculations oneself to know whether an answer makes sense or not. This would include simple estimation; picking from four or five answers the only one which was not nonsensical. If this is what people mean by numeracy then I'm for it, but I have an awful feeling that if one were to ask a politician what he means by numeracy, he would mean knowing one's multiplication tables. Don't get me wrong, I think that one should know one's tables, but one has to know beyond that.

MW. There is a considerable body of opinion, for example among employers, that children are leaving school without basic numerical skills. "Modern" mathematics syllabuses and "modern" methods of teaching are often cited as causes.

RRS. I think that the basic dichotomy is not between "modern" and "traditional" but between "instrumental" and "relational". What employers need, if they did but know it, is genuine relational understanding of quite a limited syllabus. The "modern mathematics" bandwagon could well have done as much harm as good, because the whole object of introducing such concepts as sets, mappings, one-one correspondence, etc. is to give relational understanding. If these are taught instrumentally, they have completely failed in their object and they give nothing else besides. The old-fashioned syllabus, even taught instrumentally, did at least leave pupils with a range of techniques which they could apply without understanding them fully: the limitation being that because they did not understand them properly, they had very little ability to adapt them to even slightly novel situations.

MW. What sort of provisions should we make for the special groups of children in schools? I am thinking particularly of the slow learner and the mathematically gifted child.

RRS. I would say that the way schools are structured at the moment, it is almost impossible to help either of these. How well spent are our limited resources in trying to teach slow learners anything beyond the rudiments of mathematics seems to me very questionable. In view of the tremendous shortage of mathematics graduates in schools, I think that it is almost impossible that the needs of the majority of mathematically talented children can be met, with great loss to themselves and to our country.

MW. Can you think of any sort of reorganisation that would use our resources more efficiently?

RRS. In the present context of mathematics, this might mean concentrating our mathematical teaching talent and learning talent in the same place, where they could meet each other. I do not know to what extent this is compatible with the present comprehensive school system. It would certainly involve some degree of choice on the part of parents and children in regard to which school they went to, and I think that some of the proposals for an educational voucher scheme deserve careful consideration.

References.

1 R. R. Skemp, *The Psychology of Learning Mathematics,* Penguin, 1971.

2 ————, *Understanding Mathematics,* University of London Press, 1964-71.

3 R. L. Wilder, *The Evolution of Mathematical Concepts,* Transworld, 1973.