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QUESTIONS AND DISCUSSION

Question: WHAT ABOUT LESSON PREPARATION?

HAROLD FLETCHER: It is evident that lessons that have been prepared always go better than those that have not. I get extremely worried when I hear people say: "I've been teaching for so long I've no need to prepare lessons any more." I remember an occasion when I met a certain person and suggested to him something about lesson preparation. His reply was: "But I've been teaching for thirty years!" What I felt had happened was that he had taught the same lesson thirty times, because after all, the pupils that you have this year are not the same as the pupils you will have next year. I do not think we can ever go through year after year with the idea that the same preparation is correct. I feel that on the whole teachers want to prepare lessons carefully. The method I always used was to construct a kind of flow chart of the points that I was going to try and lead the children to discuss and the points that I wished to develop. It seems evident to me that any teacher will realise that the more care that is given to the preparation of the lessons that he is going to give, the greater are the chances of success. If you want satisfaction out of the lessons you give, you will have to spend considerable time deciding which is the best way of presenting the material you want to give, what kind of techniques you are going to introduce, but most of all you must remember that the preparation that you have given to this lesson will not only be the starting off point for this lesson, but probably the starting off point for a series of lessons that are going to cover what I hope will be a continuity of purpose. So lesson preparation is vital.

If you have written your lessons in a book, you will have made your comments on each lesson as you go along. The great thing is to find out where lessons have failed, to be perfectly honest with yourself and then next time to look at that lesson and perhaps give another presentation. Of course, there is always one danger about all preparation—you may suddenly find in starting your lesson that it is going somewhere out of joint, or some child has asked a particular question that was not down on your flow chart. I feel that if a child can bring up an intelligent question that may have nothing at all to do with the lesson in hand, but nevertheless offers some mathematical field for you to explore, then it is your job to explore it and it is not your job to say: "Well, we're not doing that today, we'll leave it until later." If you can strike something that is of vital interest to the children because it has come from the children and not from you, grasp hold of it and use it; perhaps the lesson that you so skilfully prepared on Saturday for Monday will not be used on Monday at all, but on the Tuesday or the Wednesday because of something that arises in Monday's lesson.

JOHN FLAVELL: Very briefly, more or less to echo what Mr. Fletcher has said, I fully agree with him that the byways can be very much more illuminating and educational than the highways, and where an opportunity comes to go off the highways which you had not planned, then seize it. I would also add that I think the most important aspect of presentation of material is the relationship between teacher and child. If that relationship is good, a really healthy, stimulating two-way traffic relationship, then your presentation can hardly be bad, because that is the thing that really matters.

LEONARD SEALEY: With young children, lesson preparation is very different from what goes on when you are teaching at high school level. I think it would be a great shame if you expended your energies looking at a little tiny bit of the canvas when you should be looking at the whole canvas. I am sure that Harold Fletcher does not imply that there should be no teaching or that there should be teaching all the time. I think with young children, the idea of teaching is probably a false one anyway and your lesson preparation should be an evaluation of your previous experiences that you have presented to children and an attempt to improve them. Preparation, for me, is a matching of the child with the experience.

I would also like to echo Harold Fletcher's point that the best way you can spend your time is to be critical of what has happened, to really diagnose what has been done. The important thing is to go over again what you did even if you were only presenting experiences to children from a diagnostic point of view. Every experience that you have with children should help you to become a better teacher and should help them to develop. That is the only valid reason for making any sorts of marks in any books.

Question: IS THE PSYCHOLOGY OF PIAGET STILL VALID?

LEONARD SEALEY: The psychology of Piaget is a developmental psychology: it sees a stream, a developing stream and this was a new view of development, the fact that it was continuous. What Piaget did was to distinguish the stages: the pre-operational stages, the operational stages which are the concrete and formal operational stages. Piaget has been quoted as tying ages to these various stages and this has confused and disturbed many teachers because, when they looked at their own children, they found that they did not exactly correspond with what it was said that Piaget had stated.

In fact Piaget has not the slightest interest in education at all, which may surprise you. It just happened that what he was saying was useful to educationists because he was talking about the development of children.

Piaget is quoted by Eleanor Duckworth in a paper she sent me and I shall quote verbatim from it. The developmental stages that were described by Piaget were under discussion. (Actually he was talking in New York and also at Berkley, University of California.) The sort of thing that people asked him was: "Do you still say that these stages exist and do you still say that ages are related to them?" Piaget's reply was: "I have never said that ages were related to the stages." In reply to the first part of the question, Eleanor Duckworth writes: "In fact the only one of these statements that he (Piaget) would support is that children go through certain stages of intellectual development. Contrary to the view most often attributed to him, he maintains that the nature of education and therefore of experience *can* have an effect on this development." You will realise that when Piaget's work was reported, people took it as the word of God rather than the word of Piaget and they thought this was absolute. The hesitations in their hearts arose because it seemed sensible to them as teachers that the nature of the experience would affect the rate of growth through the stages and Piaget is now saying: "But of course, how could you ever have thought otherwise?"

So yes, it is still valid, with the clear understanding that the nature of the experience that we provide for children will affect the individual rate of growth through the stages. Thus, children of 10 cannot all be said to be coming to the end of the stages of concrete operations. Some of them will be at the stage of formal operations, some of them will just be beginning the stage of concrete operations and this will be a function of themselves and of the experiences that the schools have provided.

I want to quote you one other thing that is in this letter: "As far as education is concerned, the chief outcome of Piaget's theory of intellectual development is a plea that children be allowed to do their own learning. Piaget is not saying that intellectual development proceeds at its own pace no matter what you try to do. He is saying that what schools usually do is ineffectual. You cannot further understanding in a child simply by talking to him. Good pedagogy must involve presenting the child with situations in which he himself experiments in the broadest sense of the term, trying things out to see what happens, manipulating things, manipulating symbols, posing questions and seeking his own answers, reconciling what he finds at one time with what he finds at another and above all, comparing his findings with those of other children." This is in a way connected with the last question. If you are preparing to teach young children, you may be doing more harm than good, if you take the Piagetan school, the developmental psychology, as your alma mater in this respect.

To sum up, there is a psychology by Piaget called the developmental psychology, which is quite a different psychology from the other ones in that it isolates certain stages in intellectual growth. It is now fairly certain that the stages exist, but it is also certain that one experience will decide the child's rate of progress from one stage to the other, in addition to the nature of his intelligence and the nature of him as a person. Yes, it is valid, but we should bear in mind that what we do is of much greater importance than many of us at first thought.

Question: WHAT ABOUT A FOLLOW-UP TO THIS COURSE?

HAROLD FLETCHER: I feel very strongly about this as some of you may have gauged in my general conversation. I have seen here people of great vision—and I mean this very sincerely—people in whose hands I am sure there will be enormous progress in mathematical teaching. I think that it would be regrettable if these people were not given an opportunity to try and develop any new thoughts of mathematics they feel would be of value to their pupils.

I hope that you will go back to your various areas, discuss with the people who teach your subject some of the points that we have mentioned, accept or reject as you think fit, but I hope that there will grow up groups of people in various areas who will discuss this more fully. I hope that some of the things that we have suggested will be worth trying in your schools, and if you find them successful you will let others know, and if you find them

unsuccessful, you will analyse very carefully why they have failed. I would like to see those of you who are the leaders of mathematical thought here getting together groups of people around you, discussing methods, discussing any new presentation you would like to make, even discussing the syllabus relationship with what you want to do, and as a result of your meetings, you will probably invite the people who are in authority on these particular subjects and hold discussions with them.

I think that if any changes ever come that are going to be successful, they will come, not necessarily because the geniuses decide to do something, but because the middle core of hard-working teachers with not too much mathematical knowledge have found some joy in this kind of work and would like to have a try. If those in the middle stratum are happy about it and prepared to have a go, then you who are at the top of your subject can be a great incentive to them in the follow-up.

This is in the hands of the teachers. If there are things that interest you, you will press for consideration of them; if there are things that you want to bring in to your studies that are not in, you will press for those, but I hope most of all that you will meet together. I understand there are some areas where you have these groups, these societies that meet—and that is delightful to hear. I hope more may spring up as a result of this course and that you will get the blessings and guidance from those who take counsel for the teaching of mathematics in this country.

You may be interested in what happens with me. I will give it to you for what it is worth. I have an area that is impossible—I think if I go into one school a day I shall cover it in five-and-a-quarter years. In that situation it is impossible to get anything done, so what I did was to get together 18 groups that covered the area; each term I meet the 18 groups and it is there that we discuss various types of work. It is there that we ask teachers who are keen to tell us about what they have done and where they failed, what they tried, what did not succeed; we are very frank, we are very honest with each other, because we recognise we do not know the answers. I think this is an important point about it all. So from some meeting like this, often comes some great thought that gives us something to think about until we meet again, something to try. It is at these meetings that we discuss new publications, film strips, films and experiments that are going on.

To me it would be very tragic if you did not meet again. It may be that there are among you some—and you know who you are—who have that power of organisation, who have such a deep purpose that you would like to start and do this. The lead has to come from some individual teacher here who decides that he would like to call his colleagues in his area together and start discussions. He probably would ask an inspector to come along and have a discussion with them. This is how it has got to start and I should leave this country very happy if I thought that there were somewhere about ten of you here listening to me now who have the courage to try something like this.

LEONARD SEALEY: These study groups are the answer. Sparing Harold's blushes, Staffordshire has the finest set of study groups of any place in the world. It is a stimulating experience to go and meet these people. We in Leicestershire copied this idea. We had mixed groups so that the secondary people who came knew what the primary people were thinking and vice versa, and these were do-it-yourself groups. They elected a secretary and a chairman and they usually met in schools, they made tea and they met at the end of the day. They circulated from place to place, small groups of people, growing a little and depleting a little, but there was a hard core of people who were deeply concerned to improve the teaching of mathematics. This seems to me the only possible way.

Question: WHAT ABOUT CALCULATING MACHINES AND TEACHING MACHINES IN SCHOOLS?

HAROLD FLETCHER: One is always loth to say that anything does not serve a purpose in schools. In my country, we have tried calculating machines in schools; we have done an experiment with calculating machines in primary, secondary and grammar schools. From experiments done, I cannot see any real use for calculating machines in primary schools. There is motivation of course—the children using calculating machines thoroughly enjoy it, they will go on a lot longer, but some of the claims that are put out about these machines —that they will help them to discover mathematical concepts and things like that—I have not found this to be the case. In fact it has been the opposite, that the children have had to know how to do operations and the mathematics behind them before they have been able to use the calculating machines to any purpose. They have used the calculating machines purely as a quick way of doing calculations in order that they could do more mathematics.

Calculating machines have been most successful with the "A" children in the top class of primary schools who knew mathematics fairly well. These children had some fun doing a lot more examples because they used the calculating machines to save time and drudgery.

We tried an experiment with some children where we tested them on the normal operations of addition, subtraction, multiplication and division and then gave them a fortnight on calculating machines. In addition, subtraction and multiplication, their speed improved. In division, they were worse after the machine than they were before it. But don't take that as any criterion about machines.

In the secondary modern schools, they have been reasonably successful in the top sections, but I have not found machines an answer to the "C" stream.

In the grammar schools I think they have been a great success, especially in the Sixth Form where they have been doing numerical analysis and statistics. I hope statistics comes into your scheme right through from the primary school upwards in its various stages.

I have a feeling that teaching machines have an enormous amount to offer. The trouble with teaching machines, of course, is the programmes: it is the quality of the programme that will, I think, decide the success or otherwise of teaching machines. You cannot have better discipline or a better exercise than try and write a programme. It is a real test of you and of your knowledge and it is worth trying. If we can get the right programmes, then these machines may well have a lot to offer in schools. I can see them offering something by way of revision; I can see them offering something to children who have been absent from school for long periods; I can see them offering something to technical colleges; I can see them offering something in grammar schools. I believe there is a future here in these if only we can get the professional people to write the programmes that will fit in with the general work that is being covered.

LEONARD SEALEY: May I say something about calculating machines? We have a lot of these in our county. Most primary schools have one at least. Some of our secondary modern schools have batteries of them and some of our grammar schools have batteries of them as well. They are marvellous for numerical analysis and they do liberate the mind of the older student in a way that is very much in line with the work that he will be doing later on when he leaves school and goes into industry or to university. Universities, of course, use them all the time now for statistics. I agree with Harold that in the primary school, you do not want a lot of them.

There are one or two things that are rather nice on a calculating machine. For example, the idea of multiplication as an operation is very well brought out by physically turning the handle of the machine—you can actually see the continuous additive result; you can see the figures moving on the product register; you can see the multiplier and the multiplicand and you can see the different places. Perceptually it is quite an important thing, but I find calculating machines for children are a means of "extending the bowler's arm". If aborigines want to throw a stick, they extend their arm by having a longer stick and put the arrow in the end; that accelerates the thing and it goes a lot further and has a lot more power. It is like that for me with a calculating machine. For example, does the distributive law hold good for all the possible numbers, even though they are large ones? Can you think of more elegant ways of finding answers to calculations? Yes, you can, but you cannot always spend the time working out whether these laws for example, or these ideas that you have, have a wide applicability, because if you are working with pencil and paper you can make errors unavoidably and it takes time. With a machine, you can do it all in a few minutes, and for this reason I should want at least one in every primary school. They are quite expensive in Britain—good ones are about £45- even with an educational discount, and most of them are either German, Spanish or Swedish, but they will not teach you any concepts. You can look at the machine all day and it will not teach you anything. You have got to make it work by having the ideas in your mind first. You have got to programme the ideas and the machine will do the calculation. I think a machine should do calculation, but this does not mean that children should not know how to calculate or be able to do so, so I do not want to be misquoted on that.

Now this business of teaching machines—we could have a separate course on it, in fact you did have a course last year. I was looking at the report of this and I think it was Professor Linder who in his opening address said: "We educationists say: 'give us enough money so that we may without restriction make use of science and the machine and you will be surprised at what will be unlocked'." I think that there is more than a grain of truth in this. You have no idea what emotional psychosis almost has been thrown up in Britain by the idea of teaching machines. I do not like to think of this whole area in terms of machines—I would much rather think of it as programmed learning, or if you like, pre-prepared experience. This focuses attention on the important aspect, that what you are doing when you are offering a child a programme is sitting down yourself and deciding what path is to be followed in order that a goal of one kind or the other shall be achieved. This is not so very different from the very best of traditional teaching. The only difference is that the programmed learning is absolutely linked with the notion of individuality, that the ideal is to

produce a truly adaptive sequence of experiences that will change in response to the feedback that the experiences themselves produce from the pupil; in other words, we are trying to reproduce what is virtually a pupil-teacher relationship at its best. And obviously, this is not going to be achieved. The best teaching machine, the truly adaptive machine, is called a teacher. We must remember this, that if it ever came to a battle, the teacher must win because no machine can do as well. So the machine is not threatening you, but the machine is going to help you and it is going to bring to you, if the programmes are first-rate, other people's ideas presented in such a way that you can pass them on directly to children. We have tried to bring you some ideas this week and you probably mutated them and rightly, because we have been unable to communicate them directly or properly to you. Therefore if you take some of the things that we have said and try teaching them, then something will be lost. You will not have them in their pristine freshness—something will have been lost on the way. A programme put through a machine (you do not need a machine, of course, this is unnecessary in many cases) could come from the best person anywhere in the world and you could give it to your child if he needed it in your school.

One would be senseless to ignore this. The cost of producing some of these programmes is enormous. The care and thought in validating the programme is remarkable and yet they are pretty poor. No programme that I know is as good as a good teacher talking with the child about the thing and helping him, adapting and modifying the behaviour in response to the child's own reaction to the experience. But we are not living in the days of Greece when everybody could be Aristotles and you could sit at the feet of the master and listen to him and get the best from various people. It is just not like that any more. In the field of mathematics, we must face up to the fact that, in general. the people who are teaching mathematics are not good enough, that in general the teaching of mathematics is poor, that in general things are not being learned well. I believe that because mathematics is fairly easy to programme—although it has not been done well yet so far as I know—then we might expect to find some help here.

Nobody is going to learn mathematics in the early stages from a programme and we may be bamboozled into learning techniques again. A printed programme uses a rather sophisticated symbolism. It uses words, and most words are concepts—they represent classes of things. The people who have written the programmes, humble and modest as they are, have injected their own thinking mode into the things. The programme you write will not be good enough for everybody, and you try to make it more adaptive and more flexible.

You must, as professional people, be aware that these programmes will be coming around and they may be just what is needed for your pupils. You will have to decide this, and once you know what is available and once you know the needs of children, you may find a pretty good match in certain circumstances.

There is a great deal of work in programmed learning going on in my own county. We have tried experiments and have found that children learn from programmes, they remember well, they learn from a programme rather faster. We have discovered for example that you can get group learning with programmes. We have done all sorts of simple things like using pre-prepared tapes for seven-year olds who are just getting around to reading. It works very well and the teacher who has got 45 of these children has a little group working in the corner with this mobile thing we have designed. We push it around on a trolley and plug it in. In my new schools I have designed bays where we can have positions, so that pre-prepared tapes can be played from a central situation and piped round and children can communicate. This is obvious and easy. This is programmed learning. The machine is the ordinary tape recorder.

There will be a time when you must abdicate responsibility for direct teaching to something that will do it probably better than you can. A teacher in that classroom could not sit with those children and give them that sort of attention when there were 45 children in the class. So programmed learning is here to stay.

Question: IS IT NECESSARY TO TEST? HOW CAN TESTING BEST BE CONDUCTED?

JOHN FLAVELL: The less testing the better. All tests should be supplemented by a teacher assessment which will be dependent on the teacher's close knowledge of that child. But I would be the last to suggest that we do away with testing—and I am including internal testing, in fact I am concerned more with what goes on in the school by way of testing than what goes on outside. It is quite common, I believe, every Friday morning, to give tests. Is the time spent in that testing really worth what you get from it? Is it a positive contribution to the week's work of the child? Children do like tests and so do you. Otherwise would these ubiquitous quizzes be so popular? People like to measure themselves up against some kind of standard which is in effect what you do in a test.

The main trouble with testing is not so much the testing itself as what happens after, and here we are to blame. If we use tests to label children, then I think a great deal of harm can accrue. In part it is inevitable. Children will accept that they are not very good in a certain direction and will not be frustrated. It is just not true that being at the bottom every time frustrates a child. It is a very good thing it is not, because I was at the bottom of a lot of things, but I accepted the fact, I think. I realised I just was not any good at so and so, but it did not frustrate me, it did not set up some kind of nervous disorder and I do not think it does with children.

But we must not use tests, I would suggest, for this business of labelling, whether it is the labelling in classes or labelling into sets or streaming. That I think is a very real danger. We must do some testing. It is a useful check on the teacher's subjective assessment. However good a teacher is, however well he knows his children, he should measure that assessment from time to time against an objective rating, which is in effect what a test is.

How should testing be done? This is difficult to answer because, in fairness to children, you can only test what they have been taught, so the teaching has first to be orientated in the direction of testing the thought and not the slickness. The question of speed I find a most difficult one. There are even schools where they fetch a stopwatch out just before the big examinations to check speed, because so many examinations test little more than speed. It is difficult to test depth, which is what we ought to aim at, depth of thought, rather than superficial slickness which is created by this speed factor. I would suggest that this speed factor can be alleviated a little by the use of all kinds of references. I cannot for the life of me see why a child in his testing situation should not have available all reasonable references.

Try to test—and this is extremely difficult—the thought behind the material that you are testing. Test basic ideas; when you are testing fractions, test the understanding of fractions, rather than the manipulation of fractions.

I will read you now the points that my group brought up on this testing. "*Testing should be both subjective and objective. In the case of subjective assessment, the teacher needs experience, intelligence, impartiality and integrity.*" It is rather nice to see that, because behind that lies the thought that there may be teachers who do not possess those qualities. The second: "*A subjective test alone could lead to abuses and the public may demand an external examination.*" I dealt with this of course in my talk. I fully agree with that. "*Final answers should be asked for as well as method.*" That I am a little doubtful about myself. I think all that really matters in most testing situations is the thinking of the child. The final answer is of insignificant importance in most instances. Next point: "*Speed tests are not necessary.*" It is lovely to read this because practically every single standardized test in any sphere of knowledge depends basically on speed to get that scatter which the statisticians demand. You know the normal curve of distribution and we have accepted this sort of thing, in my view most unfortunately, in the past. Why must a test always scatter according to the normal distribution, because that inevitably means a large number of children get a very low mark and tend to give up hope?—"I can't do this". I think we ought to look at this very carefully and decide who is going to have the say in this matter, the teachers or the statisticians and the educational psychologists. I shall finish the quotation now: "*Speed tests are not necessary: if a pupil understands, speed in calculation will follow automatically.*" That I think is a very good point. It is one of those paradoxes of which education is full that if you want children to calculate well, you do not teach them much calculation. Teach them understanding and at the end of that process, they will calculate far better than if they practised and practised and practised along calculating lines.

Question: WHAT ADVICE DO YOU GIVE ABOUT SETS?

HARLOD FLETCHER: The advice I give to you is "try them". I believe that sets should start, must start, in the reception class. It is a language that integrates the subject. It is a language that cuts away an enormous amount of excessive verbiage that we use now in mathematics. Through sets we can get a finer pin-point definition of certain mathematical concepts. I am certain it is through sets that we can make more concise statements and through the language of sets we can see mathematics more as a whole than any other way I know. The advice I give you is this—if you are full of enthusiasm and can see its purpose, try it; if you can't, leave it alone.

Question: WHAT IS THE DIFFERENCE BETWEEN CONCEPTS AND ATTRIBUTES?

LEONARD SEALEY: Do you know the difference between an elephant and a mouse? What are the attributes that enable you to use the symbol "elephant" to represent the class of attributes of all the creatures that fit into the class? That is the difference.