CALCULATORS IN THE CLASSROOM:

PROCEEDINGS OF A SYMPOSIUM SPONSORED BY ROCKWELL INTERNATIONAL

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In December, 1974, an audience of Chicago-area teachers and student teachers participated in a unique symposium entitled: *Calculators In The Classroom*, sponsored by Rockwell International.

For nearly four hours, the invited teachers listened, questioned, and commented as a panel of university-affiliated educators talked about the potentials and promises of electronic calculators as teaching aids in middle-grades (VI through IX) arithmetic classes.

The symposium's moderator was Dr. Max Bell (University of Chicago); the three other panelists were Prof. George Immerzeel (University of Northern Iowa) and Drs. Joy Rogers and Jack Kavanagh (both of Loyola University).

All of the panelists are faculty members of the schools of education at their respective universities. Further, Dr. Bell is affiliated with the Laboratory School of the University of Chicago, and Prof. Immerzeel is affiliated with the Price Laboratory School of the University of Northern Iowa. Dr. Bell and Prof. Immerzeel hold degrees in education; Dr. Rogers is a psychologist; Dr. Kavanagh is a statistician.

This report on the symposium contains synopses of the comments made by the panelists, and of the question-and-answer session that followed the formal presentations.

DR. BELL:

"We are here this morning to announce and usher in a new revolution in pedagogy.

"To any old hands in teaching here today, this will sound depressingly familiar, because we've heard the rhetoric of revolution before. We've been told in the past that new techniques are going to revolutionize the way that we teach ... that we must all prepare for a new way of doing

things. We've all lived through films, and closed-circuit TV, and teaching machines, and programmed learning, and language labs, and computer-assisted instruction, and so on ...

"Nevertheless, in the case of electronic calculators, there is a sound basis for believing that something really new is about to happen to the way arithmetic is done - and the way arithmetic is considered - in the classroom.

"I think that there is a good reason to believe that calculators are not simply a minor advance in technology, but are, instead, products that will have a substantial effect on the world at large, and, possibly, on the classroom too.

"This morning, we will explore this possibility."

(After his opening remarks, Dr. Bell introduced Prof. Immerzeel to the audience, and noted that "George Immerzeel has been using calculators of one sort or another as teaching aids for over 10 years ... he will try to 'turn you on' to the use of calculators, and will show you how they can be used as aids to the teaching of basic arithmetic and mathematical concepts."

Prof. Immerzeel distributed copies of a student workbook he developed that contains scores of unique calculator-based exercises; Rockwell 20R calculators were distributed for audience use.)

PROF. IMMERZEEL:

"One of the first things I have learned through my experience with calculators is that you first give a calculator to someone (be he a child or adult), and then you provide the student with 'experiences' built around the use of the calculator. A teacher must resist the temptation to tell the student how to work through a problem ... to 'flow chart' the operation for him."

(Prof. Immerzeel led the audience through a series of exercises that demonstrated basic calculator operations and fundamental arithmetic principles.)

"The point I continually want to make is that the calculator will do more than just calculate. It will put a focus on ideas if we, as teachers, learn to use it properly. Initially, the calculator helps you get right answers, and it allows you to do problems that are more complex than you've done in the past. But, it can do a lot more than this if we (as teachers) learn how to design material that makes full use of a calculator's capabilities."

(A member of the audience asked: "How can a calculator help other than by doing the computation?" Prof. Immerzeel replied:)

"Because it gives you the facility to build basic arithmetic concepts as well as perform computations readily.

"Some people say a calculator just calculates. I believe it is going to increase the teacher's ability to expose children to concepts and ideas. You can take almost any subject in a middle-grade curriculum, and if you use your imagination, you can find ways of using a calculator to reinforce it.

I don't believe that the calculator will replace the other things you do in class ... I think it will support them.

"I think one of the things we must emphasize to students is that there are many things you can do better in your head than on a machine. I think we must make sure that students understand this. I don't think that the calculator will ever replace a student's knowledge of basic mathematical facts, but I do think it is going to change the level at which we operate. I think it would be silly to spend considerable time in the future teaching children how to divide three digits into five digits, but, I think it is equally silly not to teach them how to divide by two digits. They need this kind of skill, but they aren't going to get it because we say they have to have it ... they are going to get it because we build ways in which they will get it.

"The important points I want to share with you are these: First, you don't teach someone to use a calculator by telling him how to do it ... you teach by getting him to do it. In the process, he will learn a lot more than the calculation you are using as an example.

"Secondly, I believe that the calculator offers us a new way to get at basic ideas.

"Thirdly, I really believe that the calculator is going to substantially affect the mathematics curriculum. It is going to change the teaching parameters. Some things are going to become more important, some things less important. The calculator opens a complete new set of objectives in the problem-solving dimension.

"Here's an example. I happen to be involved in an experimental project in problem-solving. We are using the calculator because we can get at problem-solving in a way we never did before. Besides calculating more quickly, we can get more 'experiences' in a given period of time.

"During this project, I once asked fifth-grade kids to determine how many pieces of paper they could tear from a sheet in one minute. The teacher I was working with thought I was a bit crazy, but everyone in the class tore little pieces of paper. Then, we asked ourselves: 'How long would it take the class to tear a piece of paper for every citizen of Iowa?' And: 'How much longer would it take to tear a piece of paper for everyone in the U.S.?' These are hard problems if you are working with pencil and paper, but not if you have a calculator."

(Dr. Bell suggested that the audience be prepared to ask Prof. Immerzeel practical questions about calculator usage during the panel discussion to come later. Dr. Bell noted that Prof. Immerzeel's long-term classroom experience with calculators - first mechanical and later electronic - was "the best kind of experience to have."

The next panelist to speak was Dr. Jack Kavanagh. Dr. Bell prefaced his introduction by explaining that advice on the future use of electronic calculators in classrooms might well be garnered by studying "the lessons that have been learned about the use of mechanical calculators in the past."

He cautioned the audience, though, that "There is a sense in which this is an analogous experience, and a sense in which this is an irrelevant experience. Mechanical calculators have certain flaws and difficulties that make the classroom use of electronic calculators a new and different proposition.")

DR. KAVANAGH:

"Basically, I have compiled a technical paper. But, instead of reading it to you (and having half of the audience go to sleep) I want to summarize what we did and what our objectives were.

"Essentially, we questioned if mechanical calculators could be used to improve the achievement and attitude of low achievers in mathematics. Work done as early as 1937 showed that the achievement of normal students could be improved by the use of calculators.

"We randomly chose 125 junior high students who were at or below a 'C' average for two years. We distributed them into five groups: a pilot group; two experimental groups; and two control groups. We then ran a pilot first quarter, an experiment and control the second quarter, and an experiment and and control the third quarter.

"The pilot was used to determine methodology. We took 25 basic concepts (communitivity, associativity, and the like) and split them into 10 teaching units. We gave students a unit at a time, and asked each student to complete each one to predetermined criteria. At the end of each unit, we gave the students a test devised to measure mastery of the work unit.

"We were interested in several things. First, we looked at the achievement level at the end of each unit. Next, we wanted to know how many students in each group completed all 10 units. Finally, we were interested in attitudes, and we used a standardized mathematics attitudinal inventory to measure this.

"Our results were interesting. Although we could not measure an increase in attitudinal growth of the experimental group compared to the control group, the second quarter experimental group showed significantly greater achievement than the control group.

"We later found, though, that the situation was reversed in the third quarter ... the control group achieved better results than the experimental group. We interpret this reversal to the fact that our mechanical calculators began jamming frequently in the third quarter. Students frequently wound up with incorrect answers, or else didn't have a machine to use.

"There was one other positive result we observed. In both experimental groups, a significantly larger number of students completed all 10 units compared to the control groups. This means that even though students often got wrong answers, they were better motivated to complete each exercise. I think that this in itself says something about the use of calculators in the classroom.

"I am certain - based on my own intuitive feelings - that a new experiment using jam-free electronic calculators would show positive results regarding academic growth."

(The next speaker was Dr. Joy Rogers. Dr. Bell introduced her by noting that "Joy Rogers, like the rest of us, has been through numerous revolutions which turned out not to be. She has some advice for us about the use of calculators as teaching aids, and some ground rules for determining whether or not a new device - such as the calculator - is likely to be truly useful in a classroom."

DR. ROGERS:

"The people I really want to talk to today are the ones who influence the spending of money. I think that is probably all of you. If you walk through a school and find the dustier corners of that school, you will find a place with a sign, slightly mildewed, that says 'Language Laboratory'. Only 15 years ago, language laboratories were really 'in'. If you wanted to get a Federal grant, write the words 'Language Laboratory' anywhere in the application, and your grant would be funded. About five years ago, I noticed the mildew had started to stick to the signs, and you simply could not find any new references to language laboratories in professional or non-professional journals. The super-sensational trend lasted 10 years at the very most.

"I think we can learn something from the Language Laboratories. You are sitting there now with a delightful little gadget in your hands. Something you have enjoyed using for an hour-and-a-half or so, and something that you can see has important instructional applications. However, I think there are some cautions to keep in mind when we talk about using calculators in schools, and, more importantly, spending school money on them. I don't think the tale of the Language Laboratory need necessarily be a forecast for every instructional innovation that comes along. This one, for example, I think could be successful. I'd like to identify some things that one ought to look for in a teaching aid ... things that make it a decent and enduring teaching aid.

"Briefly, I think there are three points to keep in mind. First, I think a decent, enduring, respectable, lasting teaching aid should be inexpensive and it should be durable enough to be used by a learner. Second, I think it has to be controlled by the learner. Third, I think it has to solve problems or do things that the learner wants done.

"When I say I mean that the teaching aid has to be inexpensive or durable enough to be used by a child, I don't mean inexpensive in a relative sense. I think I mean that in an absolute sense.

"Take, for example, the cassette recorder, which is, in one sense, inexpensive. It is inexpensive enough that parents buy cassette recorder for the children as gifts. But, in the classroom the children are not allowed to use cassette recorders as if they were inexpensive. Teachers tremble if the cassette recorder is about to fall off the table or if the child does something the least bit unusual with it. Often, they are locked in vaults and

are not accessible to children except under specific instructional circumstances. Children do learn things from cassette recorders ... the ones their parents buy them. The ones in the schools don't aid learning. I feel that if something isn't inexpensive enough to let relatively unsupervised children use it freely, then it's too expensive to be a valuable teaching aid.

"An obvious essential feature of any teaching aid is that it does actually teach. That is, it responds to the learner's behavior in some consistent way that is satisfying or interesting. Notice that when you picked up those calculators after the first experience of turning them on, you had an opportunity to discover a device that responded to you. Given enough opportunity to play with it, you just might discover for yourself the kind of principles (mathematical) that a calculus professor would love to have the time to teach you.

"But, if a classroom is stocked with a lot of electronic calculators that are locked safely in a closet - except during arithmetic class, at which time they are cautiously placed on the tables to prevent any danger of them being dropped - I think it likely that the calculator will be as disappointing as the cassette recorder. To be a genuinely effective instructional tool, calculators have to be inexpensive enough to be taken to the gym, the playground, the lunch room, the band practice room, or any place where mathematical questions are of interest to learners.

"The second feature of a lasting teaching aid, I think, is a logical outgrowth of the first ... that it can be controlled by the learner. An excellent example of an existing teaching aid like this is the book. The design of the book has long given it the potential to be a useful teaching aid. Before Gutenberg, books were chained to the walls. Only monks, who would treat them very gently, were allowed to read them. But, after printing presses made them reasonably inexpensive, books became readily available to real learners. And the reader controls many of the aspects of the operation of that book.

"If those of you who are thumbing through your calculator exercises right now would look at what you are doing, you will realize how many aspects of the book you actually control. You can read it at any rate you want, you can refer to any part of it you want, it can be read in a variety of different places, or different circumstances, or even different body positions. If you get interested in the book, you can continue with the book; if you find something that I am saying interesting, you can direct your attention away from the book to me, and when I get a little boring, you can go back to your book.

"In contrast, consider something clumsy like the 16 mm motion picture projector. Most frequently the projector has to be operated either by the teacher or by a specially trained student assistant. It can't be conveniently stopped for an individual learner because it's usually shown to a large group at one time. It's difficult to assess only a particular portion of a film for reference. It is almost impossible for a student to view a film if he was absent, or whatever, anywhere other than the classroom in which it is presented at the time at which it is presented. In consequence, it's easy to find

schools that are relatively well supplied with books but have only a few relatively rarely used motion picture projectors. The point here is that an effective teaching tool needs to be at hand whenever there is a problem to be solved or any object of curiosity to be investigated.

"The calculator has the potential versatility comparable to a book. A learner can move it, or use it, in about the same range of situations that he would use a book. It is kind of amusing to speculate what the world would be like if we all had the calculator habit to the extent that so many have the book habit. You can imagine an ordinary individual thinking through some new mathematical concept with the aid of his pocket calculator ... in his car while he is waiting for a light to change ... on the computer train in the morning ... at breakfast, in lieu of his paper ... or even in the tub while he is soaking. And the size and shape of existing calculators make these uses very possible.

"The only barrier is that most people, who are now adults, have grown up without having mathematical freedom. Simply, the calculations involved in solving practical problems are likely to be so forbidding that the adult would never have thought about playing with mathematics as a pastime. If, however, it is now possible to produce a generation of children who can calculate any item of curiosity, their own baseball averages, or imaginary problems, such as how much gas would it take if we drove the car around the world - and without the computation for this sort of thing, it would be a totally burdensome chore - then maybe they will grow up to be adults who enjoy mathematical thinking.

"A tiny, inexpensive calculator ought not to present a problem for either educators or manufacturers. It is true that educators will have to begin to think of mathematics as something more than computation. The fact that you are here, and the trends that I have seen in modern math, would suggest that mathematicians are interested in teaching something more than computations.

"This leads to the third feature of an enduring teaching aid. It should solve problems or do things that the learner wants done. A good example of that kind of tool is the slide rule. But, remember, a slide rule requires user sophistication that a pocket calculator does not. They are complex, and you have to know at which end of the scale to read the answers, and where the decimal point should go. These limitations prohibit use by a nine-year-old who wants to know how many sunflower seed packages he could buy if he had a million dollars. But, an electronic calculator can give this child speculative capacity.

"I think that we will pay a price if we fail to keep these things in mind. If you want to understand fully the dimensions of that price, go back to your school Monday morning, pick up the storeroom key, and go into the storeroom. I think you will find the whole language laboratory library stored in that storeroom somewhere. You are probably going to discover several broken projectors that no one has either the expertise or the interest to fix. There are probably a couple of yellowing teaching machine programs and several crumpled audio tapes with a stack of empty take-up

reels that no one wants to use. There will be the laminating machine that no one ever did figure out how to use and probably a box of dried-out overhead projector crayons that would crack if you attempted to use them. And you might even see the acoustic coupling for the computer terminal that was taken out two years ago when the budget dried up. I don't think schools need any more expensive dust catchers, and I think storerooms are quite full enough.

"So in buying electronic calculators, let's buy them and put them in the KIDS' hands and NOT in the storerooms ... that's my point."

(Dr. Bell expanded on Dr. Rogers' comments by noting that "the classroom practicality of calculators" is an important factor in determining the ultimate utility of calculators as teaching aids.)

DR. BELL:

"I became convinced a couple of years ago, when I first bought a primitive calculator, that they were fun to use, and couldn't really help but turn kids on. But, could we safely put calculators in the kids' hands? Was it a practical thing to do?

"When calculator prices came down to the level where a few hundred dollars would buy a reasonably big collection of machines - in general, 'practicality' is a function of price - the University of Chicago bought me 25 calculators. I scattered them around the Hyde Park area in the hands of teachers I trusted.

"Some teachers I gave one or two calculators; other six or eight. My instructions were to take a calculator home, see what you think it is good for, then (if you want to) bring it into your classroom.

"My first results weren't promising. I asked a teacher: 'How do you like the calculator?' The teacher answered: 'I love it! It's a beautiful little thing ... I put it in the vault.'

"'Why is it in the vault?' I asked. 'Well,' she replied, 'I was afraid that I would catch hell if I lost the thing.' I told the teacher that the point of the experiment was to see if the machines were tough enough for kids to use ... to find out if the kids will 'rip them off' at an excessive rate ... to see if they will break down in service. I told her that the University will stand the cost of lost or busted machines. She finally did take the machines into her classroom and I received enthusiastic reports de-describing the ways her kids used them."

(In addition to the three university-affiliated panelists, Dr. Bell invited three Chicago city school teachers to comment on actual teaching experiences with calculators for the use of these teachers.

Mrs. Sharye Garmeny gave a detailed presentation recounting her experiences with two groups of students. Dr. Bell introduced Ms. Garmeny as "a gifted and perceptive teacher.")

MS. GARMENY:

"My first experience involved a summer school program for remedial students. They were young people who had not been placed in any particular grouping and were between the ages of seven and 10. They had been identified by their home school teachers as in need of remedial instruction in reading. It was necessary to divide up a three-and-one-half hour session into areas other than pure reading, and so mathematics was included.

"My initial reason for bringing the calculators to the students was to see what would happen in terms of their motivation to find out things about numbers.

"As it turned out, I had six calculators and an average of 12 young people each day. We set up an alternating schedule. No child had a calculator every day. My main interest in the beginning was just to give them out to the young people and let them see what they could do with them. One of the first and most interesting things was the fact that the young people perceived from the keys that were indicated that they could use the machines to add, subtract, and multiply. They were not too sure about that other symbol with the two dots and the slash line in between.

"They began by working out problems that they knew answers to. Well, I know that 2 + 2 = 4, and when I feed this into the calculator, does the calculator say that it is 4? It did. They began to trust the calculator. The calculator had proven itself. They knew some things and the calculator knew the same things they knew.

"Soon, they began to feel that the calculator could give them answers that they wanted. A play 'store' was set up using empty containers that the students brought from home. Here was an activity-based learning situation that allowed the children the opportunity to work with numbers in different ways. Of course, we had a cashier, and people would go to the store and shop. The cashier would use a calculator to determine costs for the people as they shopped.

"These kinds of experiences were very interesting to the young children. It was always a question of, 'When will it be my turn to do this?' and 'How accurately can I work with the calculator? and 'What kinds of things can I find out?' They checked not only the calculator, but they began to check themselves and each other.

"It wasn't necessary for everyone to have a calculator in order for the calculators to be effective. And I think this is an important fact, because if you are thinking of instituting a program using calculators, it might not be realistic to think initially of a calculator for every child.

"Multiplication became a big issue because my students wanted to find out what happened when they used big numbers. And, of course, when they would see these big answers coming out on the calculator, they would want to know, 'Well, how does the calculator come up with a number like this ...', because somehow or other their understanding of multiplication had not reached the

same level as that of the calculator. This gave me an opportunity to work with them on the distributive property. Now, we all know about the distributive property and what that does to children, but in this particular instance they were prompted to be curious about it because of something that the calculator had told them. So then when we did get around to the kind of rote instruction that consists of a teacher lecturing and students listening, they were very interested in what I was explaining to them because it was going to help them to understand something that the calculator knew how to do that they did not yet know how to do.

"The presence of the calculator seemed to make the idea of mathematics instruction more appealing to the children. The word got around and kids came from other classes to see the calculators. The students would share the knowledge and the information that they had about what the calculator could do, and they became more assured about themselves, not simply as students working in math, but as people and in their relationships with other children in the school.

"The program proved to be a very positive kind of experience for the young people, and the end-of-term evaluation suggested that they had in fact become more proficient in terms of their understanding of basic principles of elementary school mathematics.

"The second group that I am going to talk about are eighth-graders in my home school who are in a remedial class. I assume that some of you know that some of the young people we find in remedial classes are there, not purely because of their level of ability, but because of their acceptance or disapproval or dislike of patterns as they exist. I have found this to be true of some of the young people in this class. They really have good skills, but for whatever reasons, they have not chosen to indicate their skills and abilities. Instead they choose to exhibit behavior that labels them as unable to perform.

"The class is composed of twenty young people, 13 and 14 years of age, and we have a total of eight calculators. Students are grouped in clusters so that their use of the calculators again is not on an individual basis all of the time. In their initial introduction to the calculators, the questions were, 'What is this?', 'What does it do?', 'Who do they belong to?' So, initially, here again the activity with the calculator was just a kind of exploration.

"In terms of activities, their primary concern initially was in checking for accuracy. Many of the young people in the class can perform, but their rate of performance is slower than that of an average student. Their use of the calculator as kind of a follow-up experience to an exercise was really to check themselves out. If a student takes the calculator and checks himself instead of waiting for the teacher to come over, then there is more immediate response which is very important to these kids. They really cannot wait too long to find out that they are doing okay. Waiting for the teacher can delay this to the point that they lose interest and desire to participate.

"Secondly, when word problems are involved, the calculator becomes an important tool for solving problems. The question still is 'what operations

do I need to perform in order to do this problem?' And this is the question I am interested in having them answer for themselves. Because, to my way of thinking, this is what I am concerned about.

"In terms of the benefits of using the calculators, I think that one very obvious advantage is that they provide an opportunity for students to check up on what they are doing. That is very fundamental; but, calculators also motivate a kind of curiosity that I as a teacher am not always able to come up with. I have seen an actual change in the performance level of these students. I have seen an enthusiasm and a desire to really become involved in mathematics and what it means; so that as far as a teaching aid, it is a teaching aid that is very important to me now, and I think that the students can see the advantages of it."

(Ms. Garmeny's comments completed the formal presentations. Dr. Bell continued the program with a few of his own observations.)

DR. BELL:

"The question is not: 'Will calculators come to be a factor in modern life?' - they will! As price continues to drop, they are certain to be a factor in the life of every man, every citizen, because people will buy them and use them. The real question is: 'Will calculators become a significant factor in the classroom?' I believe that the answer will depend on whether or not we can find ways to exploit them for pedagogical reasons, and thus use them to advance the knowledge of mathematics in our classrooms.

"We have always had slide rules. They are very handy, but are of limited applicability. You cannot add on a slide rule, they don't place decimal points, and they require a fair amount of instruction in use. Consequently, although they are useful teaching aids, they are limited in applicability.

"At the very least, calculators give us a tool that lets kids experiment with numbers ... they provide opportunities for simple experimentation and play and fiddling, some things we don't let kids do enough.

"Early reports of their use suggest that they are highly motivating. But, I caution you that almost anything new is highly motivating for a while. Prof. Immerzeel has been using calculators long enough to be able to answer the question: 'Does the motivation wear off?' - George?

PROF. IMMERZEEL:

"The novelty of calculators is fairly short-lived. Students keep finding new ways to develop ideas with them. You will find for yourself that you need a source of things to do with the calculators in your classroom. Calculators represent a tremendous capability, but the play period is fairly short. Both you and your students need input ... you need things to do with your calculators. So, in the long run, it depends upon your imagination as a teacher as to whether or not the motivation disappears."

DR. BELL:

"Okay, so motivation strictly from a standpoint of novelty wears off quickly. But, motivation based on the opening up of new possibilities of calculator use keeps going. For example, I have seen kids use a calculator for instant verification of the things that they suspect and to check out the things that they are doing.

"For many years, I have preached that the fundamental problem with school mathematics is that there are too few links between the arithmetic pushed at the kids and the real world. Here is where the calculator can do some lovely things.

"With widespread use of calculators in the classroom, the whole artificial barrier to understanding what the world is really like ought to drop. Real-world problems - with real-world numbers - can be handled as easily as the nicely-rigged textbook problems of today.

"The clever use of algorithms, the efficient ways to do certain calculations, the generation of data and patterns, the verification of hunches, the checking out of things which the student suspects ... all of these provide possibilities for exploiting calculators in a pedagogically fruitful way.

"Let me say at once that I am not optimistic that we will do this sensibly. Some years of being in education has indicated to me that it is never safe to be optimistic about such things. I only say that there is substantial potential here which, if we behave in a reasonable way, can be exploited. Though I am not optimistic that it will be done, I say that it can be done.

"The emphasis will inevitably change if calculators become commonplace in the lives of citizens. Fractions will have very little use anymore except in order to set up ratios. Fractions will be practically useless as indeed they are already. Decimals will come to the fore very early. The business of how to place decimal points by making sensible estimates will have to come up and get attention. The artificiality in school books will no longer need to be there.

"One question that seems to come up again and again is: 'Will they get stolen by the kids?' None of the calculators I distributed were stolen. Will you comment, Mr. Nelson."

(Mr. Charles Nelson was another of the Chicago city school teachers who participated in Dr. Bell's experiment and was invited to speak at the symposium; Ms. Mary Page was the third.)

MR. NELSON:

"I have 167 students, and I believe that they feel that the calculators belong to the group as a whole. The calculators have not 'walked off', in spite of the fact that I don't lock them up. I leave them in my drawer, and everyone knows that they are in my drawer. Perhaps students inclined to take a calculator are afraid to do so because they are afraid that the group

will report on them. For whatever the reason, the calculators have not 'walked off'."

PROF. IMMERZEEL:

"We lost two calculators for a period of time, but they were recovered. The teacher who had them left them - in full view - on a shelf in an office, and so two kids had an opportunity to take them home. I don't believe there is much danger of loss in a classroom situation, but I think there may be some danger if we are not careful about visible storage."

(Dr. Bell announced that the panelists and guest teachers would now answer questions from the audience.)

QUESTION:

"What is the failure rate of calculators in the hands of students?"

DR. BELL:

"We have not had any calculators break because kids use them. However, there is a definite failure rate ... usually in the first hours of use. Reputable manufacturers will exchange calculators that fail electronically, and so astute administrators will order a few extra machines to allow for this phenomenon. If you can get over the first few uses of the machines, then they seem to work well. Also, be sure to buy your calculators from a source that offers repair facilities, because any machine will eventually need some kind of repair."

QUESTION:

"Are calculators 'crutches'?"

DR. BELL:

"There is an objection to the use of calculators that is not easily overcome ... a moral objection. I hear over and over again that it is wrong that something (arithmetic) that has always been so hard should now suddenly be so easy. There is a deep streak of puritanism in us - a kind of hair shirt philosophy - that I don't think will be easy to overcome. I recognize this in many of the arguments I hear against the use of calculators in the classroom. I think that this may be our most difficult problem after cost."

MS. GARMENY:

"If a calculator were off-limits in dealing with mathematics in life, then I would say we have an important issue here. But, then, I don't see any conflict. My experience with calculators shows that the young people still have to know how to perform the operations in order to be sure that their calculators are going about their business properly. I don't see a conflict of interest in using calculators in instruction."

PROF. IMMERZEEL:

"I would like to respond by saying that what are acceptable crutches for adults are also acceptable crutches for children. That is, if you expect adults to use calculators, then they shouldn't be forbidden to children, at least in most cases."

MR. NELSON:

"If you have a student who reaches the seventh or eight grade and who doesn't know his multiplication facts, it is pretty hard to teach them to him. What do you do with the higher mathematics that makes use of these facts? Do you stop right there with this child? Or, do you give him a multiplication table and let him do the rest of the work he has to do?

"I think of calculators like that. I would give a child a calculator to to do multiplication if it meant he could continue with other work he is required to do."

QUESTION:

"I want to modify the original question. What devices are tolerated as crutches in school?"

DR. BELL:

"What do schools tolerate as crutches? I think they tolerate (panelists, tell me if I am wrong) whatever an individual teacher will tolerate."

PROF. IMMERZEEL:

"I am bothered by the moral issues that are being raised because they are unreal. We aren't looking at the world in terms of what it really is. The calculator is not going to go away. And, in addition, the calculator is merely a tool.

"We have on a given day in my classroom something that we want to accomplish. If the calculator helps us accomplish it more efficiently, then we should use the calculator. The students are not worse off if we use calculators to accomplish a particular instructional objective. We should ask if the calculator is the best tool for accomplishing an objective, rather than whether its use is moral or immoral. I don't think that the calculator has any morality at all."

DR. BELL:

"There is a question raised here that is more than a moral question. What do you say to a school board or parent who is concerned about a student's ability to continue without the aid of a calculator in the future?

"One hopeful answer would be that using a calculator won't lead to the rotting of the student's mind, and won't lead to the loss of ability to do

ordinary calculations. I suspect we will have to document this answer by more research."

QUESTION:

"Are we doing kids a disservice by making them memorize computational facts? Is memory training an essential part of education?"

PROF. IMMERZEEL:

"It's my opinion that without basic computation reflexes you are a cripple. Why? Because I care a lot about estimation and being unable to develop a quick 'more-or-less' answer to a specific problem. To get this kind of answer you have to be able to manipulate the flow of numbers quickly and easily."

DR. BELL:

"I don't think you can do mathematics without being able to compute. I think computing is part of thinking."

QUESTION:

"What is the effect on the class if the school doesn't provide calculators for students, but some students use their own machines?"

DR. BELL:

"This problem has already come up in universities. Initially, it was answered in different ways, but now, if a student needs a calculator, he is expected to get one. Many colleges negotiate arrangements for the students to get them cheaply, or they rent them to students (often through the university bookstore)."