Steve Hunka

Prospectives in Educational Research

If educational research is really going to have influence on educational practice, it is about time. Steve Hunka reviews some of the distorting pressures that have affected and are likely to affect confidence in theoretically-based educational research, and prescribes conditions essential for that vital activity. He compares the relative weakness of educational research with the success of the physical sciences, and draws detailed conclusions for special requirements in monitoring and feedback to correct its basic theory. He then turns to a consideration of those human capabilities (such as killing area!) that have recently been extraordinarily extended through technological invention; and in a fascinating sequence he derives from among them some others (distribution of instruction, simulation of events, instructional capabilities) which promise to be peculiarly helpful in the special situation and difficulties of educational research, and which accordingly should be accepted as serving to channel the thrust of its effort.

Visions of advancement in educational research are likely to remain only idle dreams, excursions for coping with the real-world problems of today, unless we reassess our present attitudes towards, reconfirm, and where necessary expand upon, the processes by which we conduct educational research. It is my opinion that advances in educational research will be hard fought not only with those forces which govern our existence, but also amongst ourselves.

Traditionally, research has been primarily concerned with the development of theory, expressed as functional and sometimes causal relationships among variables. The development of laws in the physical sciences, expressing more precisely the functional relationships specified by theory, has led to the building of internally consistent relational and logical networks. Early research gradually established the orderliness of nature at both micro and macro levels.

The stability of such networks has been supported by the apparent recurrence of communality in nature, whether on earth or in space, in atoms or in solar systems.

But the development of theory has not concentrated solely upon the search for orderliness in nature. When such appeared not to be the case, research, particularly in mathematics, has led to the development of theory specifically designed to account for the disorderly behaviour of elements and events in nature. Thus, where randomness was suspected, theory led to laws which were idealized for a multitude of elements, as in molecular motion.

In retrospect, it is relatively easy to see that order has been built upon order, that old giants shoulder the new giants, and that the proliferation is not so much a stable pyramid but rather a series of inverted pyramids.

Of course it is easy to look back upon the successful developments in the sciences and to attribute these successes to those critical explorations only which became the basic stepping stones to success, and to ignore those explorations which failed. There is no doubt that a crucial factor in developing the high degree of reproducibility and stability which characterizes the results of research in the physical sciences has been the ability to concentrate effort upon definable and relatively homogeneous elements of nature, and so to effect a high degree of control over the experimental environment. Homogeneous elements and a high degree of control are, of course, not characteristics of research in education. This does not, however, deny the primary importance of research: it only complicates the conditions under which we must operate.

Present conditions — a nudity of mind

Moving education from the normal school to the university required that we embrace as best we could the obligations of the university community with regards to research, not only to increase our credibility but also to raise the quality of teacher training. But, while other disciplines and professions had already established much of their *modus operandi* to ensure a place for research, education had to concentrate upon this direction in the context of increasing enrolments, a lack of well-trained researchers, and a depression mentality with regards to research funding. Although expectations were that these conditions would gradually change, by a stabilization of enrolments which would provide time for research, and the provision of funds to establish the basis of both human and capital resources, this of course has not come about.

The last six years have brought about conceptions of educational research that have been distorted by pressures for the provision of immediate answers, for political and financial accountability, and for training programs to provide a basis for promotion rather than knowledge with sufficient generality or specifici-

ty to solve educational problems. Increasingly we are being seduced by the offering of contracts for the production of information and data, and this seduction is encouraged by the pressure to ameliorate the effects of budgets inadequate to cover inflationary trends. Too frequently these contracts reflect what Suppes has called "bare empiricism" and equated with "mental streaking, — a nudity of mind which is less appealing than nudity of the body" (Suppes, 1974). Bureaucrats, some of them our own students, who have missed or forgotten the point that the primary purpose of basic and applied research is to provide for the development and enhancement of theory, and who have also forgotten that the knowledge they gained while at university was not produced by the simple procedure of finding someone else's work in an automated retrieval system, are "calling the shots" and ignoring the conditions for research by demanding that creativity be interred in block diagrams of the systems approach.

A most serious problem, although directly related to funding, is not however receiving due attention. Universities possess a number of staff members who are unproductive in research, and a number who will grow old and become less productive. When these factors are coupled with almost no staff mobility, there is little chance for young bright people to join the university. In fact these conditions are discouraging potential students from entering careers in research. The long-run projection of this situation is clearly alarming. The whole university system, which with all its faults still provides the opportunity for the creation of ideas, could well approach a state of *rigor mortis,* and society as we know it today would follow.

These problems, however serious, should not distract us from maintaining our sights upon research which has theoretical significance. Twelve years ago Cronbach sounded the warning (Cronbach, 1966). Speaking about large educational dissemination projects, which today may be considered to have been replaced by large contracts, he noted that:

> . . . the hidden cost of the gift is too great, if it turns the experienced researcher into an administrator sitting atop a vast machine that grinds out normal science in which the data are untouched by the human mind.

Cronbach also noted that:

> . . . what counts is the jump in which a radical mind asks a new kind of question. In education as in other fields normal science is not enough. We must maximize the likelihood of scientific revolution.

Twelve years after Cronbach's warning, Kerlinger restated in a much stronger fashion the need for maintaining our focus directly upon educational research with theoretical significance (Kerlinger, 1977). Although many may disagree with some of his strong statements concerning the social utility of educational research (cf. Slavin, 1977), one cannot disagree when he noted that "research that is not excellent has no place in science," and that in order to train

researchers we must

> ... give (them the) best theoretical, mathematical, and methodological training possible in order to maximize excellence. Conceptual and technical competence should be our first training goal.

Perhaps we do ask our students to read theoretically-based educational research, and to note the origins of such work, but do we require them to think in a theoretical manner? Thinking and creating in the theoretical domain involves not only the specialized understandings of a primary discipline, but also at least a broad understanding of related disciplines. Theoretical explorations involve being sensitive to the real world as well as knowing how to build models to describe functional relationships. Clearly, methodological and mathematical training is necessary not only as a basis for deciding what work of others is valid, and to recognize results of analyses which are highly confounded with arithmetic artifacts, but also as a basis upon which extrapolations can be made of a theory. What must be prevented is the unwarranted generation of pseudo-theories which cause too many of our graduate students to chase after rainbows. Are we getting so myopic that in the training of reading specialists we excuse them from understanding, not just basic arithmetic, but also calculus? Do we rationalize the absence of educational foundations in the training of measurement researchers by claiming that they *do* know calculus? Have we substituted the black box of the computer for an understanding of elementary statistics?

Factors enhancing research

In a recent report entitled, "Fundamental Research and the Process of Education," submitted to the National Institute of Education by Kiesler and Turner (1977), not only has the importance of educational research been restated, but those factors believed to enhance research have also been noted. Firstly, there must be an atmosphere where criticism can flourish in the open. For the beginning or hesitant researcher, this can be slightly traumatic, but it can be alleviated by publishing research reports within one's own institution. Experience with such small beginnings may lead later to more substantial publication.

Secondly, expertise in research is essential and is not brought about by simply being familiar with a research area. We should not talk about research projects, but rather, research programs. Research programs take five to ten years to develop; they cannot be created overnight by administrative fiat. A research program is not a sequence of events dependent upon the successful awarding of a government contract which purchases answers to questions asked by someone else. It is like life itself, taking many years of nurturing before maturity is reached: however, like life itself it may be destroyed in a fraction of a second, or worse it may be tortured to death by slowly removing its nurturing sustenance.

The same report also noted the importance of time, openness. and flexibility. Excellent research does not take place in the rush of deadlines for reports, nor does excellent research come about through blind adherence to rigid specifications of research design. Speed may be fine when one knows precisely where the research is to go, but explorations and creative synthesis cannot be governed by time. Unfortunately, some agencies in need of research results have extrapolated the results of one man working for ten years as equivalent to ten men working for one year. Such an approach to educational research is ridiculous. In the context of the conditions noted by Turner and Kiesler, the researcher is, however, obligated to make a careful and continuous distinction between creativity and chaos, whether working in basic or applied research.

Only a naive person can deny the tremendous advances which have been made through research. The physical sciences make more than a "just noticeable difference" each year in their progress. Cronbach has suggested that research development and dissemination are necessary to keep the educational system moving forward. But is this enough? Do we honestly believe that the more theoretical work upon which applied research and development is based will satisfy our own needs as well as those of the educational system? Although the model of research—development—dissemination may have worked exceedingly well for the physical sciences, is there good reason to believe that it will work without modification in educational research? The physical sciences are characterized by having stronger laws in the sense of having predictability, as well as having a greater reproducibility given a set of known conditions. These laws are stronger even when probabilistic events need to be taken into account. Not only are our laws in educational research considerably weaker, and not subject to easy verification, but we may be unknowingly capitalizing upon, and perpetuating, a belief in events which are only statistical artifacts.

Future programs depend on monitoring

The point which must now be made is that the one-way street of research, development, and dissemination which has worked so well for the physical sciences is not sufficient for education. The most crucial factor which is missing is the capability to increase the validity of theory and reproducibility of results. The demand for this capability is complicated because the nature of our students is ever changeable, whether by maturation or by environment, and because our system of delivering instruction is almost totally dependent upon the human teacher.

The crucial factor missing in the research sequence is monitoring and feedback required to correct basic theory, and to refine and tune our procedures and materials at the development stage. I believe that as researchers we are behaving in a presumptuous and naive manner to think that research, development, and dissemination alone are sufficient either to enhance our theories, or to effect

that kind of development and dissemination which will lead to a better control of our educational problems. Researchers seem to be cognizant of the need for monitoring, but the research environment is too restrictive, when compared to the classroom environment, to permit the assumption that what works in one will work well in the other. Development must have its monitoring carried out in the classroom, where it is important to be sensitive to the need for correction before errors are no longer correctable.

The requirements of the monitoring process have been developed under the traditional title of measurement and evaluation, and there is little need for all these to be reviewed. There are, however, two measurement parameters which have been generally ignored. One is the rate at which monitoring takes place, while the second is the element or unit being monitored. There is no question that both the rate of monitoring and the selection of the element to be monitored are highly dependent upon the capabilities of the monitoring system. For example, it is absurd to monitor those variables related to weather prediction on a weekly basis if serious consequences due to the weather can occur within the time frame of one day. For similar reasons, it is useless to monitor the averaged measurements of several weather systems in an attempt to determine the local effect for an isolated geographical area.

Traditionally in education we have implemented monitoring programs with widely different monitoring rates: royal commissions every five to ten years, yearly examinations, mid-term examinations, class quizzes, the question and answer interaction between a teacher and a pupil, as well as the rapid observational monitoring by the teacher of behaviour directly related to learning such as the attentiveness of students. In these examples, the rate of monitoring is extremely variable, and the nature of what is being measured also varies. At one extreme exists monitoring which provides aggregate data over large groups such as produced by province-wide examinations, and at the other extreme, the continuous monitoring of a single student in the process of learning.

Regardless of whether learning is considered to be continuous or to follow some type of step function, learning progress is best identified by those methods of monitoring which are fast and made on each individual learner. Monitoring of individual progress taken over short periods of time is desirable because errors can be detected rapidly, and such data can be aggregated if needed to calculate other more gross parameters. Furthermore, errors can be more directly related to instructional content and the procedures used at a specific point in time.

In the typical classroom the fastest monitoring can be made by the teacher's observation as interaction between teacher and student takes place. However, even though this monitoring is rapid, it can only provide the monitoring of a single student. In addition, such monitoring can only be sequential or continuous if the teacher maintains the interaction with one student and ignores the

monitoring of the other students. On the other hand, if the monitoring of a single student is sacrificed in order to monitor other students, the continuity of monitoring is lost. Unless a single tutor were provided each student, it is humanly impossible to effect a high rate of continuous monitoring for each student. The implementation of more formal monitoring procedures, such as daily quizzes, to effect a more rapid rate of monitoring would result in an intrusion on the instructional activities of the classroom, such that the instruction would be degraded. Monitoring must be unobtrusive and non-degrading of the instructional activities.

With due respect to the best teachers in our classrooms, and recognizing the instructional activities which teachers are expected to carry out, it would seem hopeless to implement monitoring procedures having the characteristics just described. For in addition to the monitoring of learning, the teacher is asked to plan and execute a lesson which embodies both the logical and psychological ordering of curricula, and to make deliberate use of principles of learning and motivation, all of which must be commensurate with the development, both cognitive and psychological, of the child. The teacher is expected to carry out these activities with due recognition of the individuality of twenty or thirty children on a daily, weekly, and monthly basis. These requirements border closely upon being humanly impossible to meet.
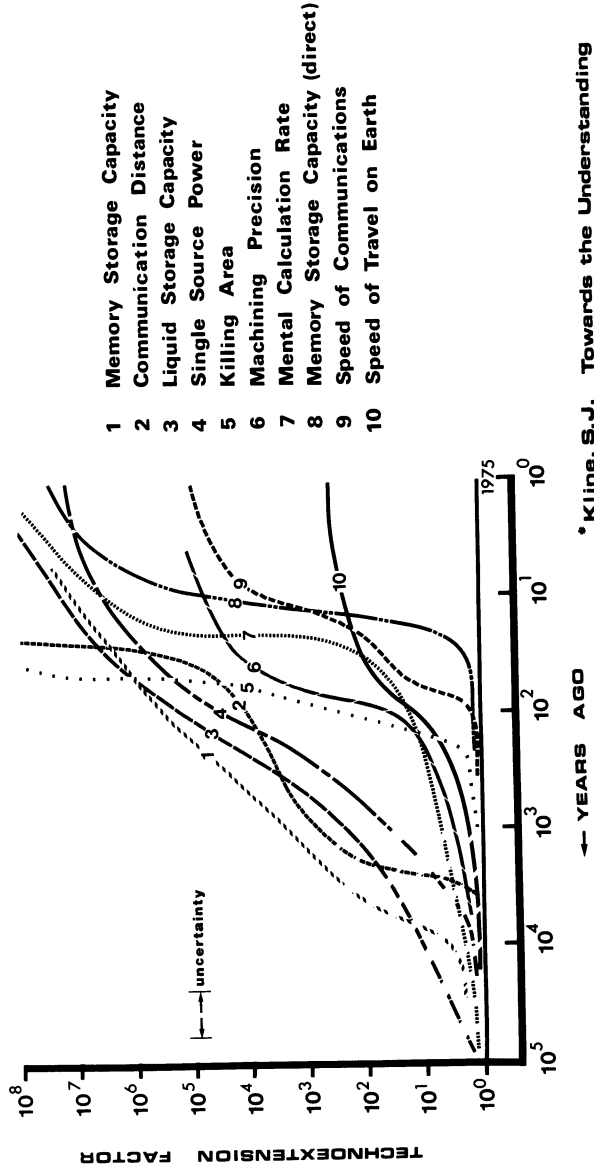
Short of the teacher having super-human powers, how might all the instructional activities, including the monitoring, be carried out? We cannot expect changes, either in the student or in the teacher, of sufficient magnitude to solve the problem. Although one cannot deny the possibility of geniuses among us, their numbers are certainly insufficient to make any appreciable and direct impact upon the problem, given our current methods of providing instruction in the classroom. We need capabilities that are more than merely human.

The extension of human capabilities

The extension of human capabilities has been rapidly increasing during the last century, and a measure of this extension has been reported by Stephen Kline of Stanford University (1977), during his acceptance of an award in fluid engineering. This measure of extension is called the "technoextension factor," and is an estimate of the ratio formed by the increase in human capability due to a technical aid, to the unaided human capacity. Thus, for example, if the electron microscope provides a magnification factor of one million times over that of the unaided eye, the technoextension factor would be taken as 10^6 to 1, or simply one million. The estimation of these ratios, or extension factors, is made in order to show the increased human capability brought about by machines as extensions of human muscles; by the lens, both optical and electronic, extending human vision; by the use of books, records, and magnetic tapes to extend the

FIGURE 1

TECHNOEXTENSION FACTORS ESTIMATED
BY KLINE*

1 Memory Storage Capacity
2 Communication Distance
3 Liquid Storage Capacity
4 Single Source Power
5 Killing Area
6 Machining Precision
7 Mental Calculation Rate
8 Memory Storage Capacity (direct)
9 Speed of Communications
10 Speed of Travel on Earth

*Kline, S.J.   Towards the Understanding
                of Technology in Society,

human memory capacity; and by the use of radio waves to extend the capability for communication.

Figure 1 shows the technoextension factors estimated by Kline for *memory storage capacity, communication distance, liquid storage capacity, power in a single source, killing area, machining precision, calculation rate, direct-access memory capacity, communication speed,* and the *speed of travel on the earth's surface.* It is interesting to note that extremely high slopes exist for such capabilities as *killing area, calculation rate, direct-access memory capacity,* and *communication distance.*

At this point in the argument the challenge created by Kline's data is to estimate the technoextension factor for instruction, to assess the extent to which instructional capability has increased relative to other human capabilities, and if this capability is found lagging, to speculate whether those capabilities shown by Kline to have the greatest growth can be used to increase *instructional capability.* To estimate the extent to which instructional capability has increased over the same period of time used by Kline is not a simple task, since instruction is compounded of the capacities of the learner and of the teacher, and by our understanding of the factors which facilitate learning.
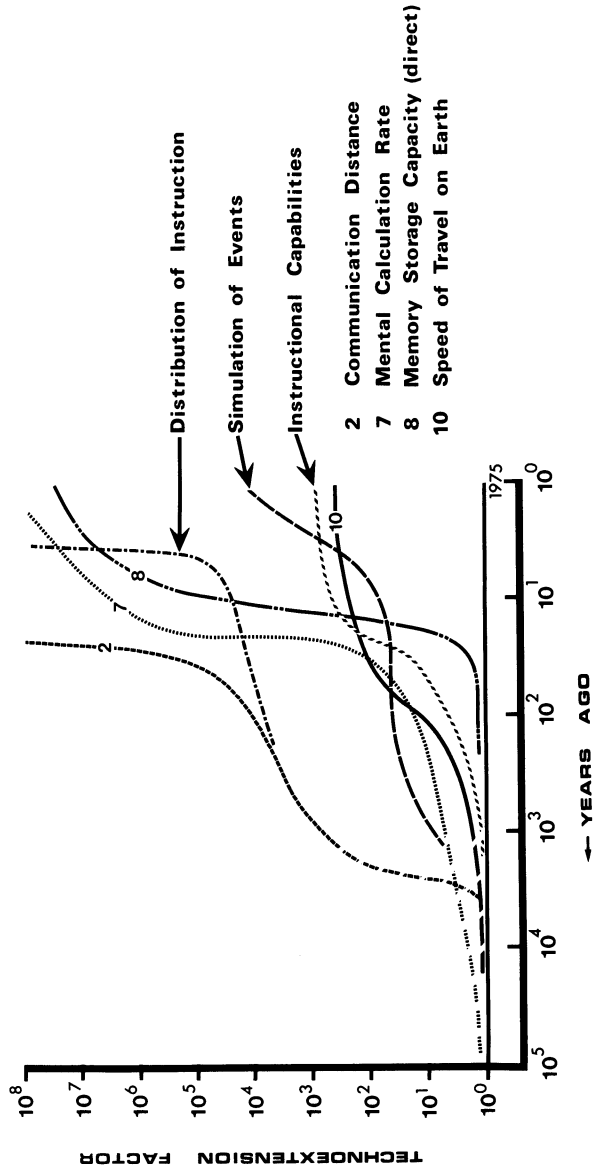
In order to estimate the position and form of a curve of technoextension for instruction it is necessary to estimate the effects of such historical events as, for example, the use of clay tablets imprinted with symbols, the development of the printing press including the printing of words and diagrams, the introduction of the blackboard, and the use in the classroom of such audio visual aids as radio, film, and television. The identification and evaluation of significant events and their dates are, of course, subject to debate. Nevertheless, I suspect that even with considerable error in over-estimation, the curve others might produce would not differ very significantly from my estimate shown in Figure 2.

I have also estimated some other curves against which instructional capability can be compared. There is no question that the *distribution of instruction* tends to follow the high slope of curves typical of Kline's data. The distribution of instruction has been markedly enhanced by the distances over which we can communicate through the use of such developments as radio and television. I would argue, however, that we are now able to distribute a suboptimal level of instruction over wider areas and larger groups. Because *simulation,* or the re-creation of events, is dependent upon *direct-access memory* and *calculating power,* it also has a very high slope. Simulation capability has only a marginal effect on instructional capability because of a low rate of utilization.

Now, one might wish to argue that those technoextension factors which demonstrate very high rates of increased capability are clearly the product of the human mind, and that surely this must reflect the instructional capabilities

158

FIGURE 2

TECHNOEXTENSION FACTORS ESTIMATED
FOR SOME INSTRUCTIONAL ACTIVITIES

Distribution of Instruction

Simulation of Events

Instructional Capabilities

2   Communication Distance
7   Mental Calculation Rate
8   Memory Storage Capacity (direct)
10   Speed of Travel on Earth

TECHNOEXTENSION FACTOR

YEARS AGO

society has developed. Although there may be an element of truth in this position, it is not a compelling argument, for the progress made in these rapidly developing endeavours represents the accumulation of theory, research, and development by admittedly bright and sometimes genius-like individuals, but it does not in itself demonstrate an application of our instructional capabilities within the educational system.

One might also argue that the technoextension curve for instruction must of necessity reach an asymptote, for *instructional capability* can only be judged in the context of the learner, and clearly genetic changes do not occur sufficiently fast to improve upon the instructor-learner interaction. I would accept this as one reason for the curve having such a small rate of change, and would also argue that it is the basis for determining how the slope for the curve might be altered. Indeed, one might view with alarm our inability to rise from the plateau shown for instructional capability in the light of some curves Kline has estimated, like the *killing area.*

Rising from the plateau

The problem now is to determine whether those technoextension factors shown by Kline to have high values can be used to raise our instructional capabilities from its plateau. In thinking about the problem I have concluded that one of the basic capacities of the teacher is communication, and that this communication is basically limited to oral communication and physical movements. These are constraints placed upon the human condition. It is crucial to instruction, of course, that communication must be of a specific nature and with content ordered by time. It seems that the purpose of this communication is to have information stored by the student, to provide the student with capabilities for communication, and most importantly to formulate and support these capabilities through the generation of thought process. These thought processes may involve both the recognition and input of external communications and the generation of new and qualitatively different thought processes.

The basic elements of instruction which might be enhanced to extend our instructional capabilities are therefore the generation of information (the thought process of the teacher), the storage of information, and communication. In the educational context communication can be supported by such technical aids as amplifiers, books, audio-visual devices, and the use of signals such as those employed in radio and television. However, it is inescapable that when one considers technical aids to communication, two conditions immediately become evident. Communication may be in real-time, that is, as it happens, or it may involve the storage of information and its later reconstruction. Thus, a very large number of technological devices involved with communication also have, inherent to their design, the capacity to store information. Therefore, in the con-

text of Kline's curves, one important extended capability must be taken to be *direct-access memory.* Storage capacity itself, although showing remarkable growth, is not as important to instruction as direct access memory, because the speed with which information can be retrieved is more important to the continuity of instructional sequences than having slow access to large amounts of information.

Another technoextension factor among Kline's curves which might be used to help raise our capability in instruction, is *calculation rate.* Although one might envisage here only simple arithmetic manipulations, the calculation rate includes making very elementary logical and relational decisions. But the high rates of calculation which have already been achieved could not have been achieved by a human deciding in real-time upon the necessary steps. However, with the storage of the steps to effect a calculation, the limitation of human input speed is removed. This suggests again the importance of *direct-access memory* capability which also was found important in communication. *Calculation rate* and *direct-access memory* speed and capacity have an important bearing upon communication, for the combination of the two provide the basis for capturing and re-creating a wide range of different phenomena. For example, the combination of calculation rate and memory provide the capability to communicate three-dimensional orthographic projections, complex drawings, and photographs in static or dynamic form, and even to recognize human speech and to simulate human speaking. Although some may believe that technical systems for the recognition and simulation of human speech are purely speculative, such systems, although crude by human standards, are already available on the commercial market and the development rate is accelerating owing to the tremendous increases now possible in calculation rates and memory capacity. The recent "Speak and Spell" unit produced by Texas Instruments is an excellent example.

The generation of thought processes, a vital component in the human condition, whether it be for the teacher or the student, is a far more difficult attribute to enhance by those capabilities shown by Kline to have high technoextension factors. The same factors which are vital to communication and to calculating rate, that is to say *direct-access memory* speed and capacity, are also important in the generation of thought processes, but only if the information stored includes the precise definition of the strategies from which super-rules can be formed and acted upon. Investigations are being made in this area under the term of artificial intelligence. One has to admit that the prospect for enhancing the capability for thought processes is limited, for now we must recognize a tautology whereby design parameters have first to be defined by humans in order to provide humans with further information and knowledge through communications.

Summary: integration by techno-extension

The question may now be asked, "What is the relationship between monitoring and technoextension factors in the context of instruction?" I have taken the position that research is of crucial importance to the eventual amelioration of problems in education, and that there must be a monitoring component added to the research, development, and dissemination phase. In addition, I have argued that the type of monitoring which is most important must be fast, unobtrusive, and non-degrading of instructional activities. When, however, these monitoring needs are coupled with the demands already placed upon the teacher, then the result can only be a further degradation and misunderstanding of the teacher-learning process, since I have suggested that a humanly impossible task already exists for the classroom teacher. Since we cannot expect a major amelioration to be brought about by genetic changes either in the teacher or in the student, we must seek other means of breaking away from this asymptotic state. If technological advances are to be used as the basis for escaping from the present state, then based upon Kline's work, utilization of those technological factors related to calculation capacity and storage of directly accessible information would seem to be most relevant. These two capabilities have very high technoextension factors and appear to be related to the needs of instruction. In addition, they are also related to the basic processes of communication and monitoring. There is only one technological development having functions capable of fulfilling these requirements. This device is the computer.

Because education traditionally has involved humans as teachers and learners, certain finite limits of capacity must be recognized. By definition, learning is taken to be learning by an organic system, a system defined by genetic and environmental factors. The only exception to this is not one of possibility, but of our intent, for work is already slowly proceeding to have computers "learn." The computer has those system characteristics which have been specifically designed to overcome certain cognitive limitations of the human. If there is any device being created in the likeness of man, it is the computer. Because of its capabilities of communication, coupled with the capability of simulating externalized thought processes given to it as ordered sequences of procedures, the computer can take on a major role in education. Because of its speed, it can integrate the monitoring and instructional functions without degradation of either.

Communication, however, is a two-way street. Simulating externalized thought processes and communicating the results to the originator of such processes can force the originator to reconsider his own thinking and to initiate a new cycle. When such communications do not result in a confirmation or a reconsideration of our thinking processes, we run the risk of amplifying and perpetuating errors.

161

Because theories of learning are weak, we must consider an additional component in the research, development, and dissemination paradigm. The additional component must be one of monitoring and feedback to correct and modulate the other basic elements. In the context of instruction, the same component which provides the monitoring can also be used to execute or simulate our externalized thought processes not only for the purposes of self instruction, but also for the instruction of others. We must, however, always keep in mind that human thought is most likely to continue to be considerably more unbounded than that of a finite computer.

As with most things in nature, a balance must be maintained not only among opposing forces, but also among sympathetic forces. Clearly, man values his social interactions, and especially those which entail mutually pleasing experiences. Educators must never forget that although the development of technology to enhance our cognitive capacities will continue for some time at an accelerating rate, the environment which this will create must be balanced by softer environments involving other creative endeavours. Such an environment can be encouraged through the development of such activities as painting, pottery, and sculpturing, not as a basis of economic livelihood, but rather as a retreat for the human artistic and social spirit. In the context of education, as we are drawn into harder technological environments, we must never forget about the social capacities of compassion, empathy, and sensitivity to needs. There will be no simulation for a loving hug to a young child. Such activities must always be enhanced in order to produce a world worth living in, for the human social capacity ranges from the depths of bestiality to the heights of compassion and sacrifice.

NOTE

This paper is a version of an address given at the annual conference of the Canadian Society for Studies in Education, at London, Ontario, June 1978.

REFERENCES

Cronbach, L. J. "The Role of the University in Improving Education." *Phi Delta Kappan* (June 1966).

Kerlinger, F. N. "The Influence of Research on Education Practice." *Educational Researcher* (September 1977), AERA.

Kiesler, S. B. and Turner, C. F. (eds.). "Fundamental Research and the Process of Education." Final Report of the National Institute of Education. Washington, D.C., 1977.

Kline, S. "Toward the Understanding of Technology in Society." *Mechanical Engineering* (March 1977).

Slavin, R. E. "Basic vs. Applied Research: A Response." *Educational Researcher* (February 1978). AERA, Washington, D.C.

Suppes, P. "The Place of Theory in Educational Research." *Educational Researcher* (June 1974). AERA, Washington, D.C.