

What Science Education Researchers
Can Tell The Development Community

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world of subjective viewpoints, rationalizations and superstitions, to a clearer view of the nature of reality. This reality is not only to be found in the world of objects, but in the nature of emotions, the decision making process, social organizations, and so on. Thus, the first major point is that the method of science, not its subject matter, is critical. Without a full understanding of the implications of this mode of thought, true e-ducation is impossible.

Scientists do research, which simply means they "look again". To re-look allows one to cast knowledge or events into a series of different frames or contexts, and observe the changes that occur. By attaching numbers to the changes knowledge is made externally verifiable. This is the formal process of scientific research. But research has two further outcomes. The first is discovery, to find out what one least expected. Discovery initially stems from questions that begin: WHAT-IF? WHAT-IF questions are the key to the entire learning process but acting upon WHAT-IF questions are often the last thing a student is allowed to do. The second outcome of research is that as paradoxes are resolved the questions change or become more precise. In all research the form of the initial question is often more important than the answer.

Who Finds Out?

The communication of research begins when an event or a process becomes reliably or statistically reproducible, even though an understanding of causality may be imprecise or lacking. We know that teaching makes a difference in the learner, even though the exact

nature of learning may be unknown. The question for all those engaged in research, not only in education, becomes one of how to disseminate information where it will count most. A major point here, is that while learning should rely on discovery, it should not require that each student rediscover the wheel. New data must be acquired and added to the existing body of knowledge. Somehow the educational process from an early age must incorporate a scientific mode of learning-for-oneself along with the more didactic mode of imparting existing information.

In the current state of affairs the communicative network of our educational system looks much as the diagram in Figure 1. In

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Figure 1 about here

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this figure the solid lines represent the actual flow of information. The direction of the arrows provides considerable insight into the strengths and weaknesses of the system. First it is obvious that the maximum input is to the classroom teacher, but this fact, which could operate in beneficial ways, simultaneously illustrates the teacher's powerlessness. The information that they receive, often in the form of mandates and sanctions, may frequently be contradictory. But the true measure of their impotence lies in their sphere of influence: the only people who listen to their voice are their students.

Academics, on the other hand, have relative autonomy. They are immune from pressure from the lay culture and from direct intervention by parents, and simultaneously immune from the knowledge that

these populations have to offer. Administrators, via Government dicta, interfere only in terms of research funding and salary structure, and not inevitably.

But what of research? Here is the backbone of our culture, the foundation of our future heritage. As the diagram illustrates research findings enter a closed feed-back loop in which only the researchers themselves inform and are informed. The question mark indicates a central problem which is addressed at this meeting. The communication process is restricted not only by specialism reflected in close-circuit journals edited by the researchers who do the research, but by polarized attitudes on the part of the two groups. There is a cynicism among researchers that communicates an ivory-tower snobbery to those in the applied realm. This cynicism is reflected in the view that research data are too complex to permit the dissemination of information to anyone other than ones' peers. One must of necessity "write-down" to make the results appear more tangible and coherent than they really are. This same snobbery also invades the media when journalists or editors assume that the lay population are too unsophisticated to cope with anything other than the most simple-minded ideas.

Those in the applied realm tend to discount the efforts of research because it is assumed that they (the researchers) are too remote from the real world, and cannot relate their ideas to real problems. At the end of the line are the teachers, who being totally removed from any information of main stream research find their classrooms invaded by zealous developmental enthusiasts who offer a brave-new-world technology or band-aid science with little regard for how the teacher is to cope. The situation is chronic

and requires considerable rethinking for any improvement to occur.

New Lines of Communication

In the diagram three avenues of communication (in dotted lines), perhaps the most crucial, are currently closed. First, it is obvious from the central position of the teacher that they should be a reliable and immensely valuable resource. To open the first avenue then, would allow input from the teacher to flow at least as far as the applied arena. This would entail not only suggestions to the developmental agencies of what is possible, and where the constraints may lie, but a greater awareness on the part of developers of the dynamics generated by good versus poor teachers. In the recent NSF report on science education, it was stated that good science teachers were obviously to be found in the system, BUT that their aptitudes and styles were "too idiosyncratic" to provide a coherent model. This is another way of stating that it is too bothersome or difficult to determine the variables that combine to produce an effective educator. If those in the applied realm don't understand these dynamics then there is little that can be applied! Table-model micro-processors are not the solution.

The remaining avenues are those that should connect the people engaged in basic research to outsiders. The first avenue must extend to the teacher, who, if informed of current knowledge in the fields of learning, problem solving and motivation, will be considerably more likely to feel confident in utilizing or applying suggestions from those in the applied domain.

Secondly, we need an informed lay population, because it is

they who set the trends and open up possibilities in any democratic society. It has often been voiced that when communicating research to outsiders the message not only becomes oversimplified but can lead to misunderstanding or even havoc. In one sense this may be true, but information will leak out willy-nilly. If we allow these leaks to be transmitted by those in control of the media this is a considerably greater disservice than if we ourselves communicate directly and repeatedly. If researchers could be bothered to write for the people, if only on occasion, the possibility of misinterpretations would be considerably lessened. After all, we educate the people, they should be trusted to read and understand what we write. The fact that academics don't trust the judgment of the people taught by those they themselves have trained, is really a scathing indictment of our whole educational system.

The Conservative Mandate

Something clearly has gone awry. It is not only that Johnny can't read, but Jenny, as a college sophomore, can't spell, and Sam as a senior can't write a grammatical sentence. Everyone agrees that no science is possible without both literary and numeracy. But this is not to say that we cast science aside in order to learn to add and subtract.

The mandate from the people is misunderstood. Science, the arts, exploration, the process of becoming self aware are seen as frills only when there are no skills. The populace has seen money poured into education, but found no return on their investment. And the people are justified in this grievance. If we were given a golden opportunity, how was it squandered and where, and why?

The fact that we need to comprehend both as a nation and as educators is that no education is possible without discipline and techniques. The drill that begins at dawn on the football field produces an excellent athlete. But if teachers must only aim to entertain this puts the classroom in competition with television and film. Skills are not acquired in passing or by osmosis. Repetition and hard work are required.

With this realization, voiced in the dissatisfaction of parents and teachers alike, science should not be seen as peripheral but central to the aims of education. The process of verification, the function of numbers, the need for proof can follow directly and in parallel with the acquisition of numerical and logical skills. Science should not be seen as something tacked on to the educational process at some remote point, but as an early and fundamental tool to learning.

And we need research. We are at the frontier of understanding how children learn. We need still to discover which cognitive strategies exist, and to determine which of these strategies lead to special talents. We as researchers must shed our reticence and begin to communicate, to disseminate facts to both educators and lay people alike. A classroom without information from relevant research, without the full comprehension of the power of the scientific method results in the perpetuation of arrogance. For in this setting anyone can be right, even though everyone is wrong.

