Unfulfilled Tomorrows

Arnold E. Ross

Early Challenges

Very few of us remember the dramatic growth of concern in the late 1960s over the lack of opportunities for minorities in education and in the workplace.

In the late 1960s,[1] we at the Ohio State University became involved in the educational component of this concern—the concern over working with young people lacking sound educational background.

We felt we should attempt to bring the basic experience of exploration (a fundamental and still much neglected issue) within the reach of achievement of a given group of students, then lead them to some understanding of fundamental ideas, and, as a byproduct of growing involvement, bring to them mastery of basic manipulative skills. Here students' reactions are less predictable than usual. The teacher must possess the capacity for improvisation in meeting surprises in the form of unexpected opportunities or unexpected difficulties. Hence the need for "master teachers".

We reported on the conceptual basis of our choice in print in 1970 in the paper entitled, "The Shape of Our Tomorrows".[2]

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Since then, unhappily, what became the prevailing practice did not provide a strong and vivid challenge. The resulting problems were deepened by the concomitant practice of segregating minority students on the grounds that they were not up to facing challenges of a demanding study plan.[3] The public view fostered by the combination of these two practices manifested itself in the lack of public confidence in the graduates. An additional negative effect has been the feeling of insecurity on the part of the younger generation brought up in this environment, the feeling which created a permanent need for special consideration in the workplace.

A growing number of talented black professionals associate the prevailing practices with "affirmative action" and object strongly to them. They feel that the public attitude engendered by these practices handicaps them in successful career development and helps to bring about such frightening predictions as found in that unhappy tract, *The Bell Curve.*[4] Sadly enough, many of our eager colleagues have their minds set on an inflexible rhetoric they call curriculum. For example, the very large Project 2061 of the American Association for the Advancement of Science lays heavy emphasis on curriculum. What seems to have been lost is the idea of allowing

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[1] Arnold E. Ross, "Windmills or Stepping Stones?", in *A Century of Mathematical Meetings,* Bettye Anne Case (ed.), Amer. Math. Soc., 1995.

[2] *American Mathematical Monthly* **77**, 1970.

[3] "A Better Idea", *The Economist* (December 2, 1995), 23.

[4] *The Bell Curve: Intelligence and Class Structure in American Life,* by R. J. Herrnstein and C. Murray, The Free Press, New York, 1994.

enough freedom of movement for the teacher to permit students to learn through exploration. Fortunately, this idea is becoming more popular in the scientific community. The Science Education Standards recently published by the National Research Council offer a blueprint illustrated by examples. The approach to science learning in the Standards has been dubbed "minds on".

The prevailing practices under discussion are sponsored by the government and are given large material support by foundations and by industry. Although it is needed, we cannot hope for a significant change in policy very soon. However, the time has come for a thoughtful discussion of what we may do to face related social, economic, and political issues. With this in view I am writing this new report on our 1969 experiment with a strong emphasis on the human facets of this warmly remembered adventure.

Pioneering

In the 1960s a very special effort was desperately needed to correct the distressing views and practices of that time. In response, our government introduced the program named "New Careers". It was meant to cajole the young minority people of post-high school age who dropped out of high school to return to school.

The government asked colleges and universities to cooperate by designing two-year accessible programs leading to a certificate of competence in some marketable skill. Minority professionals and leaders of the religious communities joined forces to reach out to young people and interest them in taking advantage of these new opportunities. Generous material support was made available.

Our university's School of Social Work was one of the early participants in the New Careers program. There was no precedent to help to visualize problems and opportunities presented by the new undertaking. Faculty members of the various departments which would be involved were called together for a discussion meeting. Everyone felt that we were embarking upon an exciting adventure. Young faculty members were particularly eager to be involved.

At the meeting every colleague in the humanities and social sciences emphasized the "relevance" of their subject to the needs of our new audience. Every one of them expressed keen regret that the officially approved academic program required two quarters of mathematics. All expected that this would prove to be an unhappy experience and would alienate our student audience.

Almost everyone felt that the language used in instruction should be the common parlance with which everyone in the new group would be familiar.

Since our mathematics department would be involved, I felt that I should attend the meeting as an observer. Moved by the general apprehension of my nonmathematical colleagues, I got up toward the end of the meeting and asked if the prospective program faculty would like me to intercede with the university and ask that the mathematics requirement be dropped.

In response to my suggestion a distinguished historian present as an observer said: "Arnold, we know that mathematics is an important part of our culture. Don't you?"

This was a challenge to which the mathematics department would have to respond adequately. Thus, following the meeting, I came to the chairman of our undergraduate committee to find out what could be done for the new group. He thought that since the mathematical background of all members of this group was practically zero, we should do remedial mathematics but try to spread the content of one quarter to two quarters.

This did not seem to be a happy solution. Remedial mathematics neither in spirit nor in content would enlighten our newcomers about the role of mathematics in our culture. I felt that one should seek an alternative. A few days later after much soul-searching I asked my chairman colleague if he would allow me to develop and teach a different required mathematics course. Suspecting misplaced kindness, he said: "All right, Arnold, but we will look over your shoulder to keep you honest."

What I took on was highly nontrivial. No attractive precedents existed. The students as well as I were equally apprehensive about our ability to reach each other. We all had to keep on learning as we went along.

It was clear to me that achieving greater mastery of mathematical ideas and skills had to go hand in hand with the growing facility in the use of language and that the movements in each must not be formally separated. This approach required that lectures and discussion periods reflect this objective. Also, it pointed up the importance of an adequate number of laboratory periods in order to provide deeper involvement and in order to prevent accumulation of new ideas outpacing the development of communication skills.

To avoid rote learning of important manipulative skills, working with elementary residue class rings seemed promising. This would provide opportunities for experimentation and discovery.

We were very fortunate in having a number of talented graduate students who were eager to help us in our enterprise, for which they felt deep sympathy. This assured us of very able laboratory staff.

I was particularly lucky to acquire one talented troubleshooter. He had just graduated from the university and was able to assist in the program. As a minority GI in Germany he learned to speak and write German. As a student he excelled in everything but mathematics. I helped him over the mathematics hump. We became friends.

The new quarter was within sight and we were set to begin. The opening day arrived only too soon.

At the outset we arranged each week for one lecture session and two laboratory sessions of two hours each. Participation by class members in the lecture-discussion was growing. In the laboratory, interchange of ideas involved in small group collaboration in problem solving proved to be very fruitful. Our choice of content seemed to suit our aims and provide a good opportunity for the students' involvement.

A small committee elected by the students helped in monitoring our progress and in maintaining our students' morale. Any news that our efforts were paying off served as a warm encouragement for our staff. At times it came in a vivid turn of phrase rather than through generally accepted idiom.

One student was asked how he liked Dr. Ross's course. He responded: "Oh, I cannot always understand what Dr. Ross says, but I always know what he does."

In the laboratory, where we encouraged collaboration, one student was trying to communicate his difficulties in understanding a problem to another one who seemed to be more confident. The fellow student listened very attentively to the end of the plea. He then responded by saying, "Here we say it like this," and, using very precise and concise English, he explained the difficulty very clearly and monitored his friend through a few first steps of the solution.

At the outset, we thought that drilling in surface manipulative skills would not serve as a response to the challenge of our historian colleague. We felt that a much deeper student involvement was needed, involvement which would lead to more thoughtful command of manipulation concomitant with a much-needed durable change of outlook. We set out to help them to view newness not as an insurmountable obstacle to personal advancement but to view newness as a challenge for exploration and an opportunity for unforeseen progress. Student response was very warm.

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To meet the challenge fully, we needed to illustrate how mathematics affects our view of the world. Fundamental ideas of kinematics seem to provide an opportunity to do this in an accessible and vivid way.

One day after the group became reasonably comfortable with exploration of mathematics, I pulled the classroom table to the front of the classroom, climbed on top of it, held my wristwatch at arm's length, and said, "Describe what will happen if I let go of my watch." In response there was genuine amusement and laughter and voices assuring me that it would break. The object of my experiment was not well chosen. I repeated my query holding my key ring an arm's length away. I actually let it drop. I repeated the experiment with several other objects, asking the class to observe carefully. Then I asked for comments.

What followed was a typical pre-Galilean dialogue: Heavier objects would fall faster, the motion was uniform, etc. We raised one side of the table to obtain an inclined plane to slow down the fall and let heavy coins slide down it. Everyone observed that the velocity was not uniform but was increasing with time. It was clear that the curiosity of the students was aroused. For the following class period we obtained a free-fall demonstration machine which would record at every second the position of our falling weight on tape through electric sparks perforation. We made numerous tapes involving a variety of weights and distributed them to students for measurement. They saw that velocity was increasing with time. Could they describe this more precisely? The successive measurements did not form the already familiar arithmetic progression. Next they tried to fit an arithmetic sequence of order two—another by then familiar sequence. It worked (serendipity!). It was by then obvious that the behavior of a falling body did not depend upon its weight. Their ability to do exact measurements and calculations pointed up the existence of an important numerical invariant—the acceleration of gravity.

That horizontal motion without friction was uniform was illustrated in the classroom by a device in which an object was sliding horizontally on a pocket of air. The group had already done some analytic geometry using vectors. This made it possible for them to explore the behavior of trajectories. A series of demonstrations in an excellent lecture room of the physics department enriched their store of observations of physical phenomena.

I felt that our group had acquired sufficient background to benefit from hands-on experience in an elementary physics laboratory. The physics department chairman was very sympathetic. He felt that I should get approval of the member of their technical staff in charge of the laboratories and said that he would tell him that he himself would have no objection.

The staff member in charge of the labs was a very thoughtful and kind man. He would like to be of help, said he, but he wondered if people who had absolutely no science at school could possibly benefit by coming to the laboratory. In the end he did agree to make the necessary arrangements.

On the appointed day I let our young assistants take our group to the laboratory. By the time I joined them almost half an hour later, they were all deeply involved in the work and hardly noticed me. The excitement was so thick you could cut it with a knife. They were actually doing science. They never dreamt that they could ever do that.

At the end of the lab period students began to leave reluctantly—still starry-eyed. One student was so deeply involved he had to be cajoled to leave.

I stayed on to help clean up. One piece of equipment required two men to move it. The kind lab chief and I teamed up. As we paused he looked up at me and said, “Dr. Ross, these are thinking people, these are thinking people. Why can’t our freshmen be like this?” It was good to feel that he was pleased with the afternoon.

The relationship with our student group continued to be a very warm collaboration effort. They recognized that they were involved in an adventure of the mind—adventure, deep, challenging, and rewarding in spite of their lack of experience. When the university unexpectedly polled our student group about the value they put upon individual courses in the program, they voted mathematics to be most relevant. This was very satisfying, especially after the strong apprehensions expressed earlier by our young nonmathematical colleagues.

The aftermath varied from student to student. It depended on the student’s temperament and on the growing awareness of special talents and tastes. Many completed their college education. One of them became a very successful electrical engineer.

After college, each of our charges followed his own life pathway depending on individual temperament and natural predilections compatible with the opening opportunities. The mechanism of “predilection” is still not well understood, even though modern instrumentation and evolutionary psychology join in giving us suggestive glimpses.

In the vivid period of social change which I recall in my account, much kindness was displayed. But displaying kindness often falls short of celebrating human dignity and creativity. These vital ingredients of life are much neglected today on every level of sophistication in bringing up our young. We all too often forget our obligation as mentors as we eagerly design our inflexible prescription in the spirit of software which we call curriculum.

After a period of two decades I still have the occasion to see that the experience of the adventure of the mind which we shared in 1969 has left warm and lasting memories in the hearts and minds of the young people involved.