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THE DESIGN AND USE OF THE NEW AUDIOVISUAL AND SELF-INSTRUCTIONAL TECHNIQUES IN SCIENCE EDUCATION

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The aim of science education is not simply for the transmission of some data and modern dogma. If this were the hope, the fast development of new mass communication devices would solve the problem. They can offer today fully conscious information through massive and continuous, pounding repetition and even subliminar inculcation.

We expect to build a new attitude through science eudcation that prepares the youngster to think by himself, arriving at objective conclusions from a set of observed data and to plan new experiments to check their conclusions, and so become able to face a fast changing world.

The building of this attitude, learning the "tactics and strategy of science" as worded by Connant, or the "process approach" (as coined by the AAAS project, and approach introduced in a much smaller scope by us in Brazil early in 1963) probably cannot be accomplished except by putting the students through the process of doing it.

When we stress the point of student experimentation, some educational authorities of the developing world imagine that the experiments are not feasible for economical reasons. It is amazing that they are investing much more in educational television including in many cases the actual sets (as TV is not yet a common media of entertainment), to plan for national education satellites. Each tool has its proper role, and no replacement can be obtained for the actual performance of an experiment, its design and observations of results, followed by conclusions and generalizations. No planner in educational economics would accept a surgeon trained with the most modern visual aids....

With the same false economy, and the misconception, which is enough to view an experiment (whose only function is to show the students that one can repeat, probably, a classical experiment without any other challenge than to do it) the classical sources of apparatus, from the developed world, supply demonstration materials. The apparatus are shiny, costly, and foolproof, and it does not matter what you do to them, the results come out correct. These types of materials which do not fulfil our needs for education, represent a large investment in many countries. A second trend was started decades ago with the designing of machine-type parts, which when assembled, in theory provides the feeling of actually doing an experiment and even designing the apparatus. In reality, further detailed guides are needed to approach the demonstration equipment, without any originality or lowering of costs. Unfortunately science equipment has remained in the hands of companies that, due to lack of innovative competition, became underdeveloped industries in a developed world and "white men selling mirrors and shiny glass beads to Indians", and the people for lack of better guidance, invested their meagre funds in this. The same lack of understanding is now present in a few centres in the developing areas of the old world, that are spending funds today for useless materials which they cannot afford to replace tomorrow. The problem is not the expending of public sources, but the lack of understanding of the aims and ways of fulfilling the laboratory equipment needs both by the producer and by the consumer of those apparatus.

The very best teaching projects in science utilize simple materials to perform very well selected experiments. The simplicity leaves room for the student to employ imagination and skill in performing the experiment. At the same time, they do not allow for misconceptions as for example, the "polarization of light occurs in the polarimeter" inasmuch as the materials used are merely the requirements to produce and observe a certain phenomena, not a ready-made shiny black box performing an experiment.

Accepting the use of these very simple materials, not as an economical handicap, but as a recommendation for better education, the developing world is in an economical situation to provide materials for actual student use.

Although it is feasible, economically, to supply the developing areas with simple materials for scientific experiments, the availability, by itself, does not represent a guarantee of use. The inquiring mind, characteristic of a child at a certain age, and an essential mechanism for its integration into the man-built world, vanishes rapidly with "education". The lack of the scientific curiosity is characteristic of the adults, and rapidly imposed on the youngsters. The more familiar a phenomena becomes, the less curiosity it arouses, becoming part of the background. The radio and television are typical examples, and practically no one using them is concerned about their basic mechanism. This is not only true in the occidental world, but maybe even more characteristic in other societies.

The role of the teacher would be to maintain this scientific curiosity and the desire to know why. Commonly, the teacher also does not possess this

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capability and moreover, is afraid of stimulating a search that he cannot control and handle. The less sure the teacher is of his capability to answer all the questions the less he will stimulate the students or a less structured inquiry will be allowed.

The teachers in developing countries have to be prepared for this change. The lack of prepared teachers, their opposition to the experimentation and inquiries of the children, represents carriers that cannot be relieved by laws and regulations. Children are, themselves, more permeable to those ideas, and can start a change.

In the case of our country, we have used this approach with success, making available for them out-of-school small kits. Used by themselves, they require a self-instructional guide. Our materials went through a continuous process of changes, and now are represented by our pocket-book kits.

These small kits are what one may call a single concept, an individual (or small group) kit. In a box of ordinary pocket-book size, we supply all materials needed and a self-instructional guide. This guide raises questions and suggests experiments, allowing the student to find the answers by investigation. We avoid as much as possible supplying the answer, thereby challenging the user to find it. About twenty-five of these units are available, and it is expected that another twenty-five can be produced within another year. These kits are available in bookstores all over the country at a price of about one dollar, and are purchased by the students, themselves, as toys or hobbies.

As we expected, students brought their kits to school and challenged teachers on the knowledge of experiments. They made the teachers realize that the absence of shiny imported apparatus (that included distilled water) were not essential for a good experimental course.

The small kits, themselves, have been adapted as classroom materials, and are reaching schools directly, at lower prices (about half the usual cost). Even at half the price, the kits are costly items to the schools. In some areas where the demand for a costly package is not felt, bulk materials may be provided for about thirty cents each. We are using them for new education trials. In countries like ours, where large efforts are being made to provide free schooling, any additional expense or extension of the use of the building and the teacher, may represent denying schools for other children. In the

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present trials, the kits are being provided in the school "libraries", a room where the youngster may work with the kit by himself (evaluation being made by pre- and post-testing). Another, more radical, experiment is to use the city library, and expect the youngster to use the kit at home. In the classroom only discussions are held and any doubts clarified, resulting in an economy of time for the building and trained teachers.

Experience obtained with these programmes, some of which began more than ten years ago, led to preparation of other sets for use by small groups in school. A large volume of this type of equipment was prepared or produced fully in Brazil and is in use. They are related to projects adapted to the needs in Brazil from outside sources (mostly US National Science Foundation supported projects), and some of our own.

In the project prepared, the resultant publication is intended to be used with the set of experiments by the student himself, working as a part of a small group. The teacher is an available counsellor, who must remain most of the time simply quiet. The book is the guide, a simple, efficient and inexpensive self-instructional device, that raises problems to be solved by the students, taking into account what they discover from the experiments.

I stressed that, by all means, the most important and essential visual aid material is the lab equipment. In combination with printed material, remarkable results can be achieved. When I characterize printed materials as self-instructional materials, I just stress their real role. Books are frequently expensive items that are carried and cared for by students, but not used. If the teacher is expected to recite the course in class, which will flow to the notebook (maybe skipping the head of the student), I do not see his role. If properly used, the book has all the characteristics of a self-instructional tool, to be used at the pace of each student.

I am not going to stress here that the book must reflect the new aims of science education. We are so far away from Gannot when we put out the first textbook of physics. Many of the textbooks of physics of today the world over, are so dissimilar to Gannot, having as the same objective the describing of the available instruments, but lacking the basic concepts of science. Poor countries imagine they can afford only poorly done books. They do not think that the most expensive items, the paper and printing, do not change with the quality of the content. The lack of proper understanding of the role of the book, what it should contain, how to illustrate it, how to make it appealing, is very frequent. Cutting cost of illustrations is common, and at the same time the ones appearing may be useless. Some classical photographs are so common, such as a view of a refinery in chemistry books which does not illustrate anything but a few metal tubes. This may go as far as a "dissectable" reactor printed in transparent paper that shows only internal walls, costing almost as much as the rest of the book. Proper use of the illustrations should be a concern especially in the areas where illustrations mean an increase in the cost of the textbook.

A word on programmed texts should be added. The analysis procedure developed by programming instruction is a very useful device (that associates with other analysis, such as the attitudes expected from students) to write proper materials. It presents a much more rational process of preparing texts than the usual indefinable expertise of the teacher. The classical form of programming did not prove beyond the doubt of value, and resulted in general in bulky (and so costly) texts that are generally boring to the brightest students. Further research is certainly recommendable on the proper use of this technique, which by no means represents the only way of a self-instructional printed material.

Audiovisual materials are of widespread use. Much progress was made from the time when in half an hour a film was expected to teach what would take weeks of regular class work. Some of those old time films are still producing damage in developing countries. Just to exemplify, a large project of film translation, involving binational funds, was established some time ago in Brazil that translates those useless materials. A number of bureaucratical authorities invested in films expecting them to replace the teacher, as well as the laboratory, and in many cases the teacher tried to get them not to work. Films are a powerful tool, if properly made and properly used. No one would imagine that a student must discover everything in the laboratory. A well exploited experiment, that brings an understanding of scientific approach, requires time, and not many experiments can be actually programmed in a regular class. The film will provide opportunity to show a number of such experiments, particularly when observation or simply doing the experiment is not feasible

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(such as some long-term experiments in biology, or those requiring high speed or low speed filming). They may be better than demonstrations, that are not easily observed by large classes, and nothing precludes the film to pose a problem of interpreting the results, bringing active participation by the students.

The idea of very short (four to five minutes), single concept films is a new revolution in visual aids. Many materials are now available of very high quality. The facilities of the cartridge (which avoids delays and problems of threading a projector) make those single concepts even more useful. For the developing countries it means using six dollar, instead of one hundred dollar films. The teacher using those single concepts can utilize them according to his plans, and is compelled to actually work with them instead of being a bored viewer. New projectors now planned by industry may produce new types of cartridges not using the loop system in self-threading machines that may be much better than those now on the market. I feel that the single conception represents the best form of visual aids for some areas of science education.

Another tool that received a lot of investment, but has not yet succeeded, is educational television. Special warning of the status of present educational television should be issued to governments of countries where entertainment television does not exist. Developed and developing countries should continue their efforts and research for a proper use of television for education, if the television already exists. This, for instance, is the case of my country which has more television sets in use than students in secondary schools, and in some areas up to five channels in operation. I would not recommend the use of television where the sets do not exist and are not in use. Its cost is very high for the efficiency demonstrated till now, not accounting for cost of production (local programmes are a must to fulfil educational requirements especially at lower levels), or to the satellites being considered.

In any case educational television should also be used with the same basic concepts in mind - the active participation of the viewer, solving problems, and doing experiments. Combinations of materials are imperative, and in England some projects using television and kits are in use. Similar plans are being made for Brazil.

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Television, a large basic investment, is not the only "gadget" that attracts fantasies of the educator or politician in the developing world. Computers are another new dividend that has certainly a potential to be explored. It did not show yet any definitive value, and should not be considered as a solution to replace manpower or financial resources to the developing world. They should profit by observing critically the results of the present trials.

The new projects introduced the attitude of the simultaneous use of several tools, each one in the actual role. This concept introduced by PSSC physics expanded, and has wide acceptance. In the Pilot project of UNESCO in Brazil, texts (programmed), labs, kits, films (loops and television pre-recorded films) were used.

The most significant educational achievement of the last decade was in science education. The developing world is compelled to make use of it, if the scope is simply to avoid a larger gap towards the advanced nations.

It is sad that the ruling powers of a large part of the developing world do not understand this basic problem. In some cases they essentially accept the apparent impossibility to change education in the modern scopes. In others they waste their resources with the external symbols, missing the heart of the approach. It is not uncommon that "experts" sent by the developed countries or international organizations help to mislead them, wasting critical periods in the development process as well as scarce funds.

There is no doubt that the developing world should profit from the achievement of the most advanced countries, but this cannot be a new colonialistic civilizatory process. The educational and scientific leadership of these countries should be the initiative and recreate locally the innovation effort.

If no other reason would exist for local curriculum innovation, I would stress the need that the primary school materials should be centred in the community problems. The scientific approach can be taught with any subject, so why not tackle the most fundamental ones, which may change the whole scope of the future of that community?

Problems like public health, increasing the production of food (by the use of proper selected seeds, irrigation, fertilizers), use of electricity and machines can be part of the curricula and used to teach students to be scientific. Instead we are trying to indoctrinate them with new preconceptions, the ones

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which the necktie wearing man has. The "civilized" man does and acts according to preconceptions imposed by results of science. They may be the right ones (you get sick due to microbes or virus, not by miasmas or witchcraft), but they are accepted by the same process by which the less educated man accepts their traditional explanations. Neither one includes in the transmission of traditional explanations a scientific attitude. The scientific explanations transmit that we have no power to replace the unscientific ones. It is word against word, not facts against superstition. To associate this change of attitude as part of the scope of science education, one should take the local problems and traditions into account, which should be developed locally. They can produce complete changes in the whole way of living that other economical projects will never achieve.

UNESCO with the Pilot projects and now UNESCO/UNDP with the science centres is providing encouragment, funds and some experts for the efforts for science innovation in the developing areas. Unfortunately they do not include the local production, in scale of low cost equipment. I have seen the distortion done to the very best new innovative curricula in science, due to the lack of available lab equipment. They became as bad as the traditional ones, when taught in the traditional way.

Believing that the kit self-instructional unit can be an important tool for fast change in the world, I would like to see the local production of those units. It is very feasible to do it everywhere. This will make local innovations possible, provide a few jobs, economize hard currency, and actually apply innovation to service the need of science education in each country. Funds should then become available for tools, a few machines, and rotating funds. In the past OECD invested some funds in this idea, unfortunately, with wrong programmes. Certainly the World Bank and other agencies can now do it with large impact. Institutions like ours, which achieve results in developed areas, can help to foster those activities, and would pick up the challenge if funds were to become available.
