Social Changes through Physics Workshops

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Introduction

In the past the Ministry of Public Education in Mexico, specifically the Institute of Adult Education (INEA), made many attempts to help citizens who had not completed their basic education; however, these met with little success. Because of this, we proposed the project "Animación en Plazas Comunitarias" (Animation in Community Centers).

The objectives of this project are for youth older than fifteen to finish their basic education and find ways to work in society. The project is composed of physics workshops in the Community Centers. The workshops are designed to increase youth retention and to encourage youth to complete their studies. The workshop topics and skills development help them find ways to fit into society and to ease their transition into the work force. When the youth are in the workshops, they understand the importance of having basic instruction. This realization is the result of seeing improvement in their basic skills in reading, writing, and doing basic arithmetic operations. The students also use computers to retrieve, apply and communicate information. We believe these skills are fundamental in helping youth complete their basic education.

The methodology of the workshops grabs the attention of the youth and makes them active participants in their own learning. At the beginning of a workshop, information is delivered in such a way as to stimulate the senses and engage the minds of the participants, getting them actively involved in the challenge or activity being presented. This is integral to learning. We then ask them to write and share with their peers everything they need to successfully complete the workshop's challenge or activity. This stimulates the imagination, activates critical thinking, engages perceptual thought, and develops communication skills. In the last part of a workshop, the students use symbols and language similar to what is used in their textbooks or in the field of study to describe the activity. This step is necessary if they are to complete their basic education and continue into a field of their choice. It gives them the tools to understand and communicate on an abstract as well as a concrete level.

This project involves two groups: a) the youth learning community (the students) and b) the facilitator teaching community (the instructors). The instructors give possession of these workshops to the students. By allowing the youth to steer the direction of the workshops, the students are empowered and the instructors learn better how to facilitate the learning process. The following words are the ideas on which we based our work with the two communities cited above. First, we deal with Bruner's fundamentals, second with ideas from the physicist Manfred Euler from Leibniz Institute, and last with the steps of the methodology and examples of some of the achievements.

Modes of Representation

Following on the success of his book 'The Process of Education' [1] Bruner became concerned with the techniques and technologies that aid growing human beings to represent, in a manageable way, the recurrent features of the complex world in which they live. He noted that the principal change in man during the past half-million years has been by linking himself with new external implementation systems rather than by any conspicuous change in morphology - 'evolution by prosthesis' as the anthropologist Weston La Barre put it. Bruner quoted Washburn and Howell [2] as evidence for this:

> It would appear that the large size of the brain of certain hominids was a relatively late development and that the brain evolved due to new selection pressures after bipedalism and consequent upon the use of tools... (the) size of brain has increased some three-fold subsequent to the use and manufacture of implements. (Washburne and Howell, 1960, p.49)

Bruner suggested that the 'implement' systems have been of three main kinds:

1. Amplifiers of human motor capacities (levers, wheels, cutting tools).
2. Amplifiers of human sensory capacities (primitive devices such as smoke signals and modern ones such as radar).
3. Amplifiers of human ratiocinative (logical thought) capacities (language systems, explanatory theories).

He stated that these are conventionalized and transmitted by the culture, particularly the ratiocinative amplifiers, which involve symbol systems governed by rules that must be shared. He also suggested that there are three systems for processing information allowing human beings to construct what he calls 'models' of their worlds, which emerge in the developing child in the following order:

1. through action
2. through imagery
3. through symbols and language

These three modes of internal representation are termed:

1. through action: ENACTIVE
2. through imagery: ICONIC
3. through symbols and language: SYMBOLIC

Initially, Bruner saw the enactive phase running from very early in life, with language being superimposed at around 18 months and imagery declining at the age of 6 or 7 years: first (he or she) comes enactive, then iconic and finally symbolic forms of representation. Bruner acknowledges in his autobiography 'In Search Of Mind' [3] that he fell into the Genevan trap of postulating a chronological straight jacket. He now feels that these modes are present throughout life and are partially translatable into one another.

Enactive Mode:

The enactive mode of representation is highly manipulative in character. It knows some aspect of reality without the use of imagery or words. Hence, it consists of representing past events through making appropriate motor responses. It consists mainly of knowing how to do

something; it consists of a series of actions that are appropriate for achieving some result e.g. sailing a boat, tying a knot, riding a bike.

Iconic Mode:

This is based on internal imagery. The knowledge is represented by a set of images that stand for the concept. Iconic representation depends upon visual or other sensory organization and is principally defined by perceptual organization and techniques for economically transforming perceptions. Although initially seen as fading from use in the child's cognitive apparatus at the age of 6 or 7 years, it is now recognized as an important element in the highest intellectual realms. Consider what Einstein had to say about his thought processes [4]:

> The words or language, as they are written or spoken, do not seem to play any role in my mechanisms of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be voluntarily reproduced or combined... The above mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in some secondary stage... (J. Hadamard, 1945)

We have a similar account of Kekule's discovery of the benzene ring in a dream [5]:

> Again atoms were gamboling before my eyes. Smaller groups kept to the background. My mind's eye trained by repeated visions of a similar kind, now distinguished larger formations of various shapes... everything in movement winding and turning like snakes. And look, what was that? One snake grabbed its own tail, and mockingly the shape whirled before my eyes. As if struck by lightning I awoke. (Anschutz, R., 1961, p.700)

And there are other examples, such as Watson and Crick's discovery of the DNA helix [6]. Bruner is suggesting that images stand for perceptual events in the same way that a picture stands for the object pictured. In many circumstances such a representation of the world has many advantages, but, as we shall see, there are also disadvantages associated with predominantly iconic forms of representation.

Symbolic Mode:

Increasingly throughout life there is recourse to the symbolic mode of representation of thought. The emphasis here is that representation is based upon an abstract, arbitrary and flexible system of thought. It enables individuals to deal with what might be and what might not, and is a major tool in reflective thinking, though as we have seen not the only one. This mode is representative of a person's ability to consider propositions rather than objects (as we have seen in the stage of formal operations), to give concepts a hierarchical structure and to consider alternative possibilities in a combinatorial fashion. Bruner [7] gives the following example to distinguish between the three modes and to show how there is a natural progression from enactive through iconic to symbolic modes of thought:

> Any domain of knowledge (or any problem within that domain of knowledge) can be represented in three ways: by a set of actions appropriate for achieving a certain result (enactive representation); by a set of summary images or graphics that stand for a concept without defining it fully (iconic representation); and by a set of symbolic or logical propositions drawn from a symbolic system that is governed by

> rules or laws forming and transforming propositions (symbolic representation). The distinction can most conveniently be made concretely in terms of a balance beam... A quite young child can plainly act on the 'principles' of a balance beam, and indicates that he can do so by being able to handle himself on a see-saw. He knows that to get his side down farther he has to move out farther from the centre. A somewhat older child can represent the balance beam to himself either by a model on which rings can be hung and balanced or by a drawing. The image of the balance beam can be varyingly refined, with fewer and fewer irrelevant details present, as in the typical diagrams in an introductory textbook in physics. Finally, a balance beam can be described in ordinary English, without diagrammatic aids, or it can be even better described mathematically by reference to Newton's Law of Moments in inertial physics. (Bruner, 1966, p.45)

Dale [8] found in Bruner's ideas a conceptual framework which related to the three main divisions of his 'Cone of Experience' in the fifth edition of 'Audiovisual Methods in Teaching.' He suggested that our experiences vary according to the degree in which they involve us physically or in thought. Some experiences call for a good deal of concrete, direct, immediate action in which we make full use of our senses and often our muscles as well. Observing something, however, requires less physical, or concrete, action than an experience of doing. And symbolic experiences have virtually all the manifest physical action removed. Dale agreed with Bruner that we begin our learning of a specific matter with a broad base of direct experience in action and gradually we omit these specific, first-hand, concrete occurrences and impressions as we come to rely on iconic substitutes or pictorial representations. At both stages, we develop a summarizing idea or symbol and when we understand a symbol we can use a word or formula to stand for everything out of which it developed.

> This visual analogy (the Cone of Experience) is one of several devices that have been set up to show the progression of learning experiences from direct, firsthand participation to pictorial representation and on to purely abstract, symbolic expression... the threefold arrangement of learning possibilities illustrates the three kinds of experience that we have found so important in the process of complete communication. In this respect it is similar to the analysis of the three major modes of learning made by Jerome Bruner. (Dale, 1969, p.108)

The Role of the Physics Workshops

From the contributions of Manfred Euler in the Second International Girep Seminar 2003 [9] in his article: *Quality Development: Challenges to Physics Education*, we obtained the next aspects for our work with youth:

> The actual teachers' scripts also set limitations to an adequate use of experiments. Experiments serve a wide spectrum of functions in physics as well as in physics instruction. Theoretically, teachers assign a crucial role to experiments in the teaching and learning of physics. Teachers' beliefs mainly reflect the following function of experiments (cf. also. [10]):
>
> - The learners should have a practical experience with the phenomenon in question.
> - Experiments have a high motivational value.

- Experiments are important to develop practical skills (observation, thorough working, use of tools and instruments).
- Experiments are an important source of knowledge.
- Experiments make abstract concepts visible.
- Naive beliefs can be challenged by experiments.
- Experiments serve a methodological function: the testing of theories and ideas by confronting them with reality.
- Experiments promote scientific inquiry methods. (Euler, 2003, p. 23)

Examples of our physics workshops are:

- Lemon Ice
- Beaks of Birds
- Vinegar and Bicarbonate Rockets
- Origami and Computers
- Knots and Magic Tricks

Following Bruner, ideas were first presented as enactive activities such as transformation of matter (lemon ice) and mechanics (beaks of birds). When youths' senses were engaged first in these enactive activities, they better understood the conceptual and symbolic representations later (cool, hot, temperature, states of matter, angle, geometric figures, etc.), and, therefore, understood the language and symbols of their basic education texts.

Methodology and Results

The methodology we used was based on the 4MAT system developed by Bernice McCarthy [11]. The steps of this methodology were related to instructional design to improve skills in writing, reading, arithmetic calculation and use of the computer, and supported our hypothesis that participation in the workshop activities would lead to success in participants' later studies and jobs. Modeling the 4MAT system, workshop activities were covered as follows:

1. Liberation of the information/Engagement of the learners
2. Assessing understanding/Skills practice
3. Knowing the outcomes/Synthesizing their learning
4. Connecting and motivating
5. Sharing and developing the connection/Using the learning meaningfully
6. Critiquing the work and expressing their understanding

The liberation of information was the first step in engaging students and gave them the materials for the enactive activity; this step was a guided action. Later, through homework or in a second session, students demonstrated their understanding and through practice gained mastery. When students were actively participating in hands-on activities and discussions, it was easy to assess whether the intended outcomes were being met. Whether they had synthesized and were excited and motivated about the learning was also obvious.

After these steps, we used tools of the Internet: email, chats and blogs. One can see what students have learned and shared with one another at www.plazacomunitariacarrasco.blogspot.com. By using the technologies of information and communication (TIC), we could assess the work done by the youth. They were also able to

assess their own understanding of the material through these on-line sharing techniques. With TIC, they gained practice in iconic representation before making the jump to symbolic representation as well as honed communication and computer skills. Students were actively engaged in their own learning. Finally, students were ready to extend and refine what they have learned by moving into the realm of symbolic language used in their texts.

By the end of 2005, we had collected information and recorded positive results of the application of this methodology. For example, in the state of Aguascalientes, 120 facilitators developed courses and workshops, based on our model, in twenty Community Centers, which helped increase the participation of the youth. The youth in these centers were able to connect their learning experiences to potential jobs. In another example, in Community Centers in the south of Mexico City the students showed enthusiasm, confidence, a sense of self-worth and, most important, new knowledge that went beyond the content of the workshops. The students left the Community Centers motivated to continue learning, a skill that is fundamental to being successful in our society. In some Community Centers, students using information from the workshops started growing vegetables hydroponically, a non-traditional technique in parts of Mexico. Students have also been self-motivated to paint murals in the Community Centers after participation in art workshops. In summary, these Community Centers now focus on integrating daily life and work with basic skills and literacy, giving the students tools that they can use to improve their lives.

References

[1] Bruner, J.S. (1960) *The Process of Education*. Cambridge Mass.: Harvard University Press.

[2] Washburn, S.L. and Howell, F.C (1960) 'Human Evolution and Culture'. In S. Tax (Ed) *The Evolution of Man, Volume 2*. Chicago: University of Chicago Press.

[3] Bruner, J.S. (1983) *In Search of Mind*. London: Harper and Row.

[4] Hadamard, J. (1945) *An Essay on the Psychology of Invention in the Mathematical Field*. New Jersey: Princeton University Press.

[5] Anschutz, R. (1961) 'August Kekule'. In E. Farber (Ed) *Great Chemists*. New York: Interscience Publishers.

[6] Watson, J.D. (1968) *The Double Helix; A Personal Account of the Discovery of the Structure of DNA*. London: Weidenfeld and Nicolson.

[7] Bruner, J.S. (1966) *Toward a Theory of Instruction*. Cambridge, Mass.: Harvard University Press.

[8] Dale, E. (1969) *Audiovisual Methods in Teaching (3rd Edition)*. London: Holt, Rinehart and Winston.

[9] Michelini, M. editor (2004) Q*uality Development in Teacher Education and Training.* Second International GIREP Seminar 2003 Selected Contributors. Italy. FORUM.

[10] Harlen W., Effective Teaching of Science: A Review of Research, SCRE, Glasgow, 1999

[11] www.aboutlearning.com