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ABSTRACT

This paper states that there is a tradition of inquiry learning in science that dates at least to the 1950s and early 1960s. Inquiry learning approaches are still in fashion in that the teacher facilitates learning and a hands-on approach to actively involve students. Process approaches are still being used, and the aspects of science education that were stressed in the early 1960s are still relevant. Inquiry teaching, however, has not advanced very much since the early 1960s, because teachers do not seem to be well prepared to handle student inquiry because they lack background knowledge in the sciences or the resources necessary to teach science. Some of the problems in implementing an inquiry learning approach are identified. Communication and acceptance will be required to work out a solution to these dilemmas. (Contains 11 references.) (SLD)

Assessing: Inquiry Learning in Science

Marlow Ediger

ASSESSING: INQUIRY LEARNING IN SCIENCE

Inquiry learning in science has a long history dating back to the early 1900s. John Dewey (1910) wrote the following with the writer underlining the word "inquiry' in each direct quote in this manuscript:

The business of education is forming effective habits of discriminating tested beliefs from mere assertions, guesses, and opinions, to develop a lively sincere and open minded preference for conclusions that are properly grounded, and to ingrain into individual's working habits methods of inquiry and reasoning appropriate to the various problems that present themselves.

The National Defense Education Act of 1958 (NDEA) provided much money to improve science, mathematics, and foreign language instruction. Schools which formerly had little in the area of science equipment could now receive ample funding to buy materials and supplies for improving the curriculum. Why was this possible? The Soviet Union sent up the first satellite into space called Sputnik in 1957. The Soviet Union and the United States were in very keen competition to be the leader in the world in space, in science, and in other feats. The writer was an elementary school principal during the latter 1950s and early 1960s. Grants were written and easily approved to secure needed science equipment, materials, and supplies to develop a quality science curriculum whereby inquiry learning and a hands on approach was emphasized (See Ediger, 1975, p 107). During the 1960s, scientists and science educators were heavily involved in developing and improving the science curriculum. Inquiry approaches were numerous and in the offing. Science- a Process Approach (SAPA), and Elementary Science Study were and still are two well known hands on programs which emphasized the following:

1. Emphasis is placed upon experimentation to be performed by children upon objects, events, and/or situations in order to find answers, rather than "ready made" answers for them to accept.
2. All projects are concerned with the process of science inquiry.
3. Opportunities are given the child to develop an understanding of the structure of the discipline.
4. All projects are designed to help children broaden their understanding of the environment.
5. School experiences are expected to result in behavioral change (Gatewood and Osbourn,1963).

In further elaborating upon common features of these science projects to enhance inquiry learning, Blough (1984) wrote the following:

1. The role of the teacher becomes that of a guide to learning rather than that of a fountain of knowledge to children.
2. Scientists and classroom teachers have been actively involved

in most of the projects in determining content, methods of instruction, and general development.

3. There is emphasis upon involvement and “hands on manipulation” on the part of the learner...

4. Some new subject matter not previously included in the elementary curriculum has been introduced.

5. In many cases, there are specifically designed laboratory equipment and materials.

6. Many textbook series and other printed materials are being patterned after the project philosophy and are being used in the schools.

7. In many of the projects, concepts of a more abstract nature are introduced earlier in the learning experiences of children.

8. There is less emphasis upon subject matter as such and more emphasis upon on processes -- on learning how to learn --on emphasizing discovery and creative and critical thinking.

9. The experiences are characterized as being “open-ended.” There may be several solutions and answers; and the activities may lead into other activities.

10. There is emphasis upon exactness. Many projects stress a quantitative approach and emphasize the development of mathematics skills.

The above named trends of the early 1960s still sound very much up to date in that

1. the teacher facilitates learning and does to lecture to students.

2. educators and scientists work cooperatively in developing the science curriculum.

3. hands on approaches with active involvement by students is strongly stressed.

4. new subject matter is being brought into the science curriculum, such as new findings in science content as well as an integrated curriculum.

5. science materials of instruction are strongly recommended in the science curriculum.

6. science textbooks do change in terms of a changing society such as a multicultural emphasis.

7. more complex subject matter is introduced to students due to state mandated high standards and high stakes testing, among other factors. In some cases, science is being deemphasized presently with it being omitted in state mandated standards; reading, writing, and mathematics (the 3rs) receive major emphasis in state wide testing. Thus, there is a strong dichotomy between what science educators recommended in the curriculum and that which is implemented by different states in mandated testing.

8. process approaches are still advocated as much as ever by

specialists in science teaching.

9. problem solving is a very salient trend in science today with problems being identified by students with teacher guidance in an atmosphere of openness.

10. mathematics is the language of science and thus stresses exactness in measurement (See Ediger, 2000, Chapter Fifteen).

The National Science Teachers Association (1971), sounding very up to date for the early 21st century, stated the following as the goal of science education:

"... should be to develop scientifically literate citizens with the necessary intellectual resources, values, attitudes, and inquiry skills to promote the development of man as a rational human being."

What was recommended in the early 1960s in science instruction is still very relevant today. Pierce (1991) wrote:

According to the National Science Education Standards, all children should have the ability to do scientific inquiry by fourth grade (National Research Council, 1996). They should be able to ask questions; plan and conduct simple investigations; employ simple equipment and tools to gather data; use data to construct reasonable explanations; and communicate investigations and explorations.

Several years ago, I attended the Exploratorium Institute of Inquiry through the Keystone Science and Technology Grant (a NSF local systematic change grant based in Montana). In this workshop, teachers experienced inquiry and the underlying structure involved in using inquiry in the classroom. I became convinced that using inquiry as a teaching method was valuable and that content as well as inquiry could be taught in this manner.

Inquiry teaching in science then has not made much headway since the early 1960s.

Pierce (2001) found the following reasons for teacher hesitancy to use inquiry in teaching science:

* Inquiry takes too much time.
* When students develop their own questions, the questions do not relate to the required curriculum.
* Teachers are uncomfortable sorting questions (Harlen, 1997).
* Teachers feel unprepared to help students with difficult questions, due to a lack of background information.

In response to the above named reasons as to why teachers do not use inquiry approaches in teaching/learning situations, it is relatively easier for teachers to

1. lead a guided discussion rather that use open ended questions and problem solving in inquiry approaches to learning science.The teacher then may control what transpires in the classroom and can

proceed with the lesson more economically in terms of time.

2. subject matter coming from the teacher in ongoing lessons makes for more feelings of security as compared to the unknown coming from students in the classroom.

3. science teachers responding to the uncertainties of learner questions require much subject matter which may not be in the repertoire of the instructor at the needed time. However, with a structured presentation, the teacher may prepare ahead of time that subject matter which will be needed in a lesson presentation.

Problems in Implementing Inquiry Approaches

With much money having been available through the NDEA Act of 1958, schools received readily available funds to purchase science equipment, and science teachers received stipends to attend workshops and other professional training courses and sessions. Those were the days of visible federal funding in education. Why hasn't science instruction since 1958 not been able to develop and maintain inquiry procedures in teaching science? Certainly, the momentum, funds,and effort were there initially. One thing which has been lacking is input from pubic school teachers as to why inquiry leaning has made little headway, assuming this has truly been he case, since the days of the NDEA Act of 1958. Most of the articles written in educational journals, pertaining to improving science instruction, have been written by university professors. Very few professors do write for publication, and yet in most cases, the time is available to do so. At the same time, those professors who do write tend to be quite proliferate. Many times, the same professors write for leading journals in education. Ideas then are repeated and rephrased in these manuscripts. Thus, it would be good to

1. hear from many more public school science teachers and school administrators on how to improve the science curriculum. Articles published by those not in public school science teaching tend to be highly critical of what transpires in the classroom.

2. hear more from different professors in science education, not the few only, on what they perceive are problems in teaching students. Science educators on the university level who teach part time in the public schools might well have enlightened comments to make. Many professors left public school teaching due to the demands made upon these teachers and the low inherent status. Low salaries were a further reason for making the transition from pubic school to university teaching.

3. hear more from public school teachers as to why inquiry inquiry procedures have failed to materialize in the instructional arena. Personal accounts should be given of the local classroom involved.

4. hear more from workers at the work place on problems involved in using inquiry approaches in science learning. Meaning needs to be

attached to vocabulary used in the discussion.

5. hear more from parents on why inquiry approaches are not used more fully in teaching science. Terms used need to be clearly defined. Perhaps, parents desire a subject centered curriculum devoid of most hands on approaches in teaching science.

6. hear more from the lay public on true willingness to adequately fund a science orientated classroom with an appropriate student/teacher ratio.

7. hear more from state governors and legislators to ascertain how state mandated testing and high stakes testing influence the use of hands on inquiry approaches in student science learning. A debate could follow with public school science teachers responding to governors' and legislators' comments and vice/versa. The author believes that many so called reform efforts are lacking in debate, critical and creative thinking, as well as problem solving, leading to shallow ideas pertaining to assisting each student to achieve as optimally as possible. Teachers may spend an inordinate amount of time in drilling students for test taking, especially with high stakes testing in the offing. Many states omit science from what is being tested on a mandated test. The feelings then are that science is unimportant and the the three r's matter only or largely, since they alone are on most state mandated tests.

8. hear more from students in the public schools as to how much emphasis should be placed upon teaching science and which methods work best in the instructional arena. Students need to be aware of methods of acquiring knowledge used by scientists, such as inquiry approaches of instruction. Students too should have a say so as what to stress in the curriculum as well as methods to use in teaching and learning situations.

9. hear from a blue ribbon committee who have studied a quality science curriculum, and these committee members then should come up with a series of recommendations in designing a relevant set of objectives, learning opportunities, and assessment procedures to ascertain student achievement.

10. hear from state departments of education involved in developing high standards or goals, and state mandated exit tests on the possibilities of emphasizing inquiry procedures in the assessment process.

There are definite needs for improved communication among and between pubic school teachers and professors in higher education on improving the science curriculum. Too frequently, university professors believe that what they recommend should and can be implemented in the public school science curriculum. The lay public reads about test scores from any test taken by pubic school students and believe the test to be "GOD." News accounts pertaining to the pubic schools appear to be anything but favorable. These accounts emphasize the negative without considering any relevant factors. Narrowing or eliminating gaps in achievement between the rich and the poor are definitely not understood by news reporters. Thus, it behooves all in society to communicate more effectively with others and try to solve identified problems rather then be highly critical of student test results. A single test, by no means, describes a student's achievement and progress. The following questions need consideration when looking at and analyzing student test scores:

1. who developed the test and who was involved in writing the test items?

2. what was the purpose of developing the test? When in Putnam, Massachusetts (Education Week, April 18, 2001), 94% failed the English test, 95% failed in mathematics, and 91% fell short on the science test, for tenth graders, according to the <u>Massachusetts Assessment of Comprehensive Skills</u>, then the motive for testing and reporting the results are questionable. Who was unprepared, the test writers or the students?

3. was the test valid, be it face, construct, predictive, or concurrent validity? How was the validity described?

4. were pilot studies made to refine and develop the test? Poorly worded items need to be eliminated or modified. Item analysis provide feedback from printouts of student test results.

5. how was reliability determined for the test to be taken by students, be it test/retest, split half, and or alternate forms?

6. what might be the correlation between a student doing well on a test and being successful later at the work place? Workers on the job at the work place are not tested to notice achievement, but rather are assessed on how well the actual work was performed in being accountable.

7. what kind of environmental conditions are necessary for optimal testing situations? Was this being followed when administering the pilot study test, as well as when the high stakes test was administered to students in the classroom?

8. what kind of time limits were given to students in taking the state mandated test?

9. were the directions clear in administering the test? Vague, hazy directions do not permit optimal student test results.

10. how polite were the test administrators in giving directions for student test taking? Rude, impolite, aloof, and hostile administrators of the test in the classroom hardly permit optimal test results from students.

Test taking then has many involved variables which influence student test results. It takes time, much money, workers, and effort to produce a test which will stand up to stringent criteria for measuring learner achievement. Then too, there are philosophical considerations such as

1. would the daily products and processes of student learning be a better indicator of achievement as compared to testing?
2. how do portfolios as a way to evaluate student achievement compare with the testing and measurement movement?
3. why are workers at the work place not tested instead of evaluated on how well they do their job?
4. can one test in high stakes testing cull out whatever the student has achieved in the classroom throughout the school year?
5. what subject matter should be put into a test, and what needs to be left out?
6. which curriculum areas should students be tested in when state mandated testing is emphasized? Should state mandated testing be concerned with the 3rs only? Does that slight the other disciplines in the curriculum?
7. might selected learners be more talented in the non-academic such as being future good carpenters, plumbers, carpet layers, and automobile mechanics, among others? How can provision be made for these talents in a paper/pencil test oriented culture?
8. may state mandated tests be set at an appropriate level of difficulty in terms of numbers of students passing the test, rather than having a high rate of failures from the test results and then saying students are unprepared?
9. who needs to be involved in society to determine how public school achievement should be evaluated?
10. how can diagnosis and remediation be emphasized from state mandated test results for each student (Ediger, 1995, 246-251)?

There are problems and difficulties involved in the present situation in ascertaining student achievement in the public schools. These dilemmas need to be analyzed and ultimately synthesized. There is much work to be done here. It will take quality communication and acceptance to arrive at a rational solution.

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