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ABSTRACT

This document is a collection of papers dealing with science achievement and teaching and learning strategies. The first paper, "Quality in the Science Curriculum," discusses quality objectives, quality learning opportunities, quality methods of instruction, quality in the philosophy of education, and quality evaluation procedures. It argues that for learners to achieve optimally, science teachers need to select objectives carefully, emphasize the best learning opportunities, implement methods of instruction that encourage learners to grow, develop, and attain as much as possible, use a philosophy of education that guides students to do as well as possible in ongoing science lessons and units of study, and assess learner progress effectively. The second paper, "Reading Achievement in Science", describes methods that science teachers can use to guide student reading and emphasizes the need for higher levels of cognition in science reading. The third paper, "Portfolios and the Pupil," discusses the development and use of portfolios to indicate the quality of school work that has been accomplished. The fourth paper, "Improving the Science Curriculum," discusses realism, experimentalism, idealism, and existentialism in the science curriculum, and the psychology of education. Contains 22 references. (JRH)

SCIENCE ACHIEVEMENT AND THE PUPIL

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QUALITY IN THE SCIENCE CURRICULUM

Teachers need to continuously appraise the quality of the science curriculum. An updated set of objectives for student attainment must be in the offing. Learning opportunities for students to attain the chosen objectives need to be provided so that each student may achieve as much as possible. Evaluation procedures to ascertain learner progress should be valid and reliable.

Quality Objectives

Science teachers must examine each objective carefully to determine its worth. In an era of the explosion of knowledge, there is much for students to learn. It behooves the teacher to choose with utmost care what students are to learn. Care in selecting objectives stresses that teachers weigh the values of each knowledge, skill, and attitudinal objective. Do these have worth for student achievement? Knowledge objectives must contain worthwhile facts, concepts, and generalizations for student acquisition. Vital skills should incorporate critical and creative thinking, as well as problem solving objectives in ongoing science lessons and units of study. A hands on approach in using science equipment in a well supplied laboratory setting is a must. Quality attitudes come about when students individually have been successful achievers. Continuous optimal progress from each learner aids in developing wholesome attitudes within students. The science teacher must secure the interests of learners in teaching- learning situations for positive attitudes to accrue. Obtaining the interests of students in the science curriculum is a powerful factor in achieving good attitudes as well as in attaining knowledge ends.

Quality Learning Opportunities

Learning opportunities need to provide for individual differences among learners so that each may learn as much as possible. These activities must be meaningful and possess clarity. Purpose or reasons for learning should be in the offing for students. A variety of activities should be in the offing so that students individually may attain optimally. Thus, textbooks, video tapes, video disks, slides, filmstrips, tradebooks, and experimentation as learning opportunities should guide each learner to achieve as much as possible. Activities should be in the offing which meet the styles of learning of each student. Pupils learn in different ways and approaches. They need to have the materials of learning which guide each to attain as much as possible. Variety of learning opportunities is needed so that an activity is there to stimulate, encourage, and motivate individuals to achieve in an optimal manner.

Quality Methods of Instruction

Science teachers must use diverse methodology in teaching-learning situations to provide for individual differences among students. An inductive procedure has much to recommend itself in science. With induction, the teacher guides learners to identify problems in a contextual situation. The problems come from learners and are owned by these students. Interest in learning should be high if pupils have selected the problem areas to be solved. Following problem selection, pupils cooperatively need to achieve an hypothesis directly related to the problem. The hypothesis is tentative, not an absolute, and is subject to testing using a variety of data sources such as the learning opportunities and activities discussed above. Students through inductive means of learning are actively involved in securing answers to their very own questions. The science teacher serves as a resource person and guide, not a lecturer nor dispenser of information.

To vary methodology used in the science curriculum, the instructor may use a deductive procedure of instruction. Here, the instructor provides meaningful explanations, clearly and accurately presented, to learners. Communication moves from the instructor to learners in deductive methods of instruction. However, teachers need to assist students to apply that which has been learned. Thus within a science experiment, learners can make use of what the teacher has explained.

In addition to inductive and deductive methods of instruction, the science teacher may write precise, measurably stated objectives fo. student attainment. These objectives basically leave no leeway for interpretation as to what will be taught. The teacher may announce to students what should learned as a result of instruction. Students then have security in knowing what is expected of them as a result of teaching. After instruction, the teacher measures if learners individually have been successful in goal attainment. Objectives not attained by any one student require a different teaching strategy so that success in learning for each learner is a definite possibility.

Student input and choice may be stressed in the science curriculum. This procedure is different in degrees from that of problem solving. A student may then choose an activity which does or does not stress problem solving. A contract system night well be used here. In a contextual situation, the learner with teacher guidance plans what the former is to attain. Student input and determination is highly significant. The tasks enumerated in the contract need to be completed within a definite time. Thus the student and the science teacher date the contract as to when it is to be completed. Both sign the contract. The learner is responsible for completing what was agreed upon in the contract. He/she sequences his/her own learning in the contract since the tasks therein nay be completed in any order. A psychological curriculum is then in evidence.

Quality in Philosophy of Education

The science teacher should use a philosophy of teaching whereby each student achieves as weii as possible. An idea centered curriculum may be emphasized here. The science teacher then chooses vital subject matter to teach to students. Important facts, concepts, and generalizations are selected by the teacher for learners to achieve. An idea centered science curriculum emphasizes mental development of learners. Mental development and maturity are salient goals for student achievement. Ideas attained by learners are thoroughly discussed. A competent, academically inclined science teacher is necessary to truly stress an idea centered curriculum. Students are appraised in terms of having achieved abstract content in an idea centered science program. Concrete and semi-concrete experiences are emphasized as they guide learners to achieve in the abstract phase of learning.

A second philosophy could well stress a project method of instruction. Within a lesson or unit of instruction, the learner selects a project which he/she would like to develop. Thus, the student with teacher guidance has a purpose or reasons in mind for doing the project. Planning is done to bring the project into being. The plans or goals are then carried out in a "learning by doing" classroom climate. Resources are needed to carry out the plans of the project. Criteria that are valid and reliable are developed and used to appraise the quality of the project.

Which are selected projects that students could complete depending upon the their state of readiness? As a supervisor of student teachers (ST), the writer has noticed learners make anemometers, wind vanes, barometers, model folds, faults, and volcanic eruptions, as projects supervised by the ST. The project planned and completed depends upon and must relate to the unit title being studied in science.

A third philosophy emphasizes measurement driven instruction (MDI). With MDI, the science teacher chooses learning opportunities that harmonize with the predetermined objectives of instruction. These objectives are stated in precise, measurable terms and developed on the state level generally. The state developed objectives are then mandated for all teachers to implement. Criterion referenced test are used to measure learner attainment. These tests are valid in that they measure against the objectives of the test. Test items usually contain a multiple choice format. Instructional management systems (IMS) advocate exactly the same philosophy as the state mandated objects. Both approaches stress MDI. IMS tends to be a district level approach to note student progress whereas state developed MDI are stressed to emphasize teacher accountability in the curriculum. Teachers then must guide students to attain the stated objectives or they are not perceived as being responsible individuals for their learners' achievement. Selected states have wanted to dismiss teachers if their students do not do well on the criterion referenced tests. A major problem always exists here in that it is unknown how high any one student should achieve on a test.

Quality Evaluation Procedures

The science teacher must use the best methods of evaluation possible to determine student progress. Thus, the teacher may use observational approaches, discussions, norm and criterion referenced tests, anecdotal records (written, dated descriptions of each learner's achievement covering definite intervals of time), journal entries (student recordings of daily work completed), logs (committee summaries of what was learned on a weekly basis), and diary entries (committee endeavors in writing summaries pertaining to what was learner on a daily basis).

In a quality evaluation program, the science teacher is attempting to ascertain progress and achievement of each student. Also, the science teacher can do a better job of determining which learning opportunity to present next in sequence as a result of having appraised learner attainment to the best possible.

In Summary

Students individually deserve the best science curriculum possible. Learners must achieve optimally. The science teacher then needs to

1. select objectives carefully for learner attainment.
2. emphasize the best of learning opportunities so that each student may achieve the stated objectives.
3. implement methods of instruction which encourage learners to grow, develop, and attain as much as possible for each student.
4. use a philosophy of education which guides students to do as well as possible in ongoing science lessons and units of study.

5. asses learner progress effectively so that appropriate sequence in learning is evidence.

READING ACHIEVEMENT IN SCIENCE

Reading in the curriculum area of science is vital. it is a way of identifying problems within the context of reading. Reading can also be an approach used to develop an hypothesis as well as test hypotheses. Reading is a skill that can complement a hands on approach in learning relevant facts, concepts, and generalizations pertaining to different units of study.

There are definite methods that science teachers should use to guide student reading in ongoing lessons of study.

Guiding Science Reading

I have supervised student teachers in public schools for thirty years and have observed what appears to assist learners to achieve well when engaging in reading activities in science. These student teachers guided learners to be able to identify unknown words prior to their actual reading of subject matter in science. Possible new words to be encountered by students in reading science content were printed in neat manuscript letters on the chalk board. A few student teachers would print the possible unknown words within a sentence framework. In either case, the student teacher would observe pupils to see that they looked at each word being introduced carefully. Sometimes, the student teacher showed a picture or object directly related to the new word printed on the chalk board. Meaningful learning is very important. Thus, pupils should understand what is read and taught. This was in further evidence when the student teacher had pupils use the new words in sentences. If necessary, the student teacher would use the new word in a sentence that would harmonize with the content to be read in the science textbook(s).

Pupils tended to make minimal mistakes in word recognition when the student teacher introduced assumed unknown words to pupils prior to the actual reading of content. I believe strongly that pupils who do well in science tend to be good readers also. If pupils do not read as well as is necessary, they should be assisted by the science teacher to comprehend abstract symbols effectively so that meaningful learning takes place. Scientists in a laboratory setting do much reading since this is an important way of acquiring needed information. The teaching of science is not a reading course, but pupils need direction to identify needed words so that necessary subject matter can be found in a problem solving situation. When words are introduced to pupils prior to the actual reading of content, learners sometimes make interesting discoveries such as words that are antonyms or synonyms. Vocabulary growth and development are important in reading science materials.

Prior to reading science content, the teacher should use pictures or other audio- visual materials to assist learners to secure background information. The necessary background information guides pupils to attach meaning to subject matter read. Pupils should not be word callers. They must understand what has been read. Using visuals or real objects that directly relate to the facts, concepts, and generalizations read will help pupils to understand abstract words encountered. I find that learners very frequently identify problem areas when viewing the pictures which make the abstract comprehendible. These problem areas then provide reasons for reading. Reading is then done to secure answers/ hypothesis to identified problems. Additional learning activities will be needed so that pupils develop reasonable hypotheses to problem areas. Experimentation should be the heart of the science curriculum with reading subject matter as another related avenue of learning.

After learners have completed the reading activity for the designated lesson, they may then pursue follow up experiences. Thus, pupils might use seminar methods to discuss in depth the subject matter read as well as the results of other learning activities. The seminar stresses depth, not survey learning.

Science teachers should always notice the kinds of errors pupils make in reading. Diagnosis is then in evidence. The following kinds of pupil errors in reading science content should be evaluated by the teacher;

1. mistakes made in sound/symbol relationships in reading. The science teacher might then provide pupils with help in phonics as it is needed to understand content read.

2. weaknesses noticed in pupils not being able to divide words into syllables so that each word is identified in a meaningful manner. There are common prefixes and suffixes which pupils may learn to recognize that have much transfer value from one situation to the next, e.g. "un" for a prefix and "ful" for a suffix. Once a word has been divided into meaningful parts, a pupil may almost immediately identify the unknown due to knowing the pronunciation of selected parts, e. g. not being able to identify the word "uneasy." However, when the pupil divides "uneasy" into component parts, he/she recognizes "un" and "easy." The two syllables are then blended to pronounce correctly the word "uneasy."

3. difficulties in using context clues. If a pupil does not recognize a word when reading science content, the teacher should ask learners to provide a word that fits in with the other words in the sentence. Too frequently, pupils provide a guess that is ridiculous for the unknown word. Certainly, pupils should provide a word that makes sense in relationship to the surrounding words in the sentence.

Higher Levels of Cognition

Pupils should reflect upon subject matter encountered. To reflect requires thought. Thus pupils should think critically pertaining to ideas gleaned. When pupils think critically, they separate fact from opinion, fantasy from reality, and the relevant form the irrelevant. Learners may also detect content errors while reading. Pupils then must reflect upon the subject matter read so that understanding and concentration are in evidence. Also, learners will retain content longer if reflection upon ideas obtained is emphasized. A good science teacher realizes that pupils need to become good readers since reading is one avenue of learning, among others.

Higher levels of cognition also require that pupils think creatively pertaining to ideas obtained. With, creative thinking, pupils secure originality of ideas. Uniqueness and novelty of response are salient in the creative thinking domain.

Problem solving procedures as skills are vital for all pupils to develop. To solve problems, pupils need to be curious individuals who have a desire to learn. Reading is one way to obtain necessary information to solve problems. Thus to solve problems, pupils need to identity a problem area, develop an hypothesis, test the hypothesis, and revise the hypothesis if needed. In each step of problem solving, learners may read from the science textbook or/and tradebooks e.g. pupils might identify one or more problems in science through reading. Generally, additional learning activities will be in the offing so that pupils may select and solve problems in depth rather than use survey approaches.

In Conclusion

A quality program of reading in science stresses learners acquiring vital facts, concepts, and generalizations in ongoing lessons and units of study. Reading, along with other activities and experiences, should provide a variety of endeavors to secure pupil interest. Various endeavors also guide the science teacher in providing for individual differences in the classroom so that each pupil might learn as much as possible.

Reading in science needs to emphasize higher levels of cognition. Thus pupils develop skills in critical and creative thinking as well as in problem solving. Learners need to achieve optimally in science. The world of science surrounds everyone and has made for inventions and technology that truly are outstanding and revered.

Students individually or in committees with teacher guidance need to develop a portfolio to indicate the quality of school work that has been accomplished. Isele (1995) raises questions and provides answers pertaining to portfolio development. The following are provided:

What are student portfolios? A purposeful collection of work that illustrates the student's efforts, progress, and achievement in given areas.

What is the purpose of a student portfolio? Portfolios provide an ongoing and authentic record of student performance that enable:

students to reflect upon and articulate their own progress.

teachers to tailor instruction to the students strengths and needs and to use the student's work as the basis for instructional planning.

parents to gain greater insight into their child's learning.

administrators/ policymakers to base decisions about student achievement on authentic and meaningful information.

What are benefits of portfolios? Portfolios

* portray student's processes as well as products.
* involve students in reflecting upon their own learning, and thereby, promote individual responsibility, self- sufficiency, and active involvement.
* increase the time spent on learning and the quality of teaching.
* represent what students can do in a variety of real life situations.
* provide a tangible and meaningful basis for discussions among students, teachers, and parents.
* link curriculum, instruction, and assessment.
* inform instruction.

Portfolios then go beyond the recording and viewing of test scores of student achievement. Norm and criterion referenced test results are included, but not the sole content to use in appraising learner progress. Teacher written test results may also be incorporated into a portfolio for the individual student. Student teachers and cooperating teachers whom I supervise in the public schools assist their students to develop portfolios. Items placed in a portfolio by students have included the following:

1. written work pertaining to prose, poetry, outlines, summaries, and journal writing.

2. art work and construction activities completed.

3. snapshots of dioramas and models developed in ongoing lessons and units of study involving activity centered methods of teaching.

4. videotapes of dramatic experiences in different curriculum areas.

5. computer software completed on image processing endeavors.

6. cassette tapes of recorded speeches and talks given by the learner involving a variety of purposes.

7. recordings of oral reading and reader's theater.

8. student records in responding to computer assisted instruction (CAI) lessons and units.

9. written products from using the word processor.

10. self evaluation by the student using rating scales, check lists, diary entries, and logs.

A wide variety of products and processes should be in evidence in a portfolio. Interested, responsible persons, especially parents, may then see the quality of work performed by a pupil. The evidence is there for parents and others to see what the learner has accomplished and what needs to be worked on to further progress of the student.

Collins and Dana (1993) suggest that four kinds of data or evidence be in a portfolio. These are:

1. artifacts are documents normally created or used in schools such as tests, book reports, work sheets, projects, etc.

2. reproductions are items that typify events of activities in which students normally engage but often are not captured. For example, audio/ video taped discussions, presentations or photographs of projects, or other work.

3. attestations often take the form of a letter prepared by someone other than the student verifying his/ her work or contributions.

4. productions take two forms, both of which are especially created for the portfolio. The first is a reflective entry which articulates what was learned from the the project or activity. The second is a caption affixed to each portfolio entry describing what it is and why it is included.

Pupils with teacher guidance need to have definite categories in mind when having the former develop a portfolio. These identified categories assist the learner in thinking about how to organize the portfolio and its contents.

Strengths of Portfolios

Teachers and administrators need to look for better means of evaluation of pupil progress than what was used previously. Changes need to be made when moving from what is to what should be. What should be is based on the best thinking possible in education. Using test scores to reveal learner progress and achievement was weighed and found wanting. Norm and criterion referenced test results provided some data on pupil achievement, but the scope was very narrow in showing what a pupil knows and can do. Test results provide numerical scores, such as in norm referenced tests results indicating how one pupil compares with others in taking the same test. Or in the case of criterion referenced tests if a pupil has or has not achieved predetermined objectives. Numerical results do not indicate how well a person communicates orally or in writing. The tests also are taken outside the framework of the ongoing lesson or unit of study being presented. Pupils then lack ownership of indicating how well they are doing in each curriculum area.

The portfolio shows actual work of the learner be it in oral and written communication, construction work and art endeavors, dramatic experiences, and the making of models, among others. Gilman and Rafferty (n.d.) list the following advantages of portfolios:

1. they evaluate both product and process.
2. they allow an integration of learning and assessment.
3. evaluation is not limited to a single score.
4. they provide more information about a student's progress.
5. they encourage students to take charge of their own learning.
6. students feel they are part of the assessment process.
7. they help develop the skills for life-long learning.
8. they may actually reduce the daily burden of grading papers.
9. the information gained from portfolios is meaningful and substantial.
10. they provide a continuous example of a child's work in a context that is relevant and understandable.

11. they assess global understanding and thinking skills.

12. it is a form of evaluation that is bound to have parental approval.

Gilman and Hassett (1995) indicate three broad purposes for developing portfolios. The first is that purpose should be involved in portfolio development. Thus reasons exist for pupils with teacher guidance working on portfolios for the former. Portfolios provide information to teachers, parents, and administrators as to what a pupil has learned and achieved. Portfolio content might also be used for diagnostic purposes in determining where specifically a pupil needs more assistance in learning. Remediation might then be provided to fill these voids. The concepts of diagnosis and remediation are important in teaching/ learning situations. Second portfolios chart interests and growth of a pupil. Learners may indicate specific areas of growth and achievement. Thus which curriculum area is the pupil experiencing the most achievement? What interests does the learner possess such as in what has been written in self selected topics? Third, opportunities are provided pupils to engage in higher levels of cognition when deciding upon products and processes that should or should not go into a portfolio.

Pupils are actively involved in portfolio development. they are not passive recipients of knowledge here. A hands on approach in learning is emphasized. Portfolios have become important in revealing what pupils have learned and achieved. The state of Vermont requires pupils with teacher assistance to develop portfolios for the former. Bimes-Michalak (1995) wrote the following pertaining to the portfolio zone:

> It is easy to see why portfolios have beer embraced. According to research and a growing number of teachers, they link assessment to instruction, document growth over time, give...ownership and responsibility for... learning, making learning more collaborative, inform instruction, and communicate assessment information to parents, school officials, and the public. They are an assessment tool every classroom needs.

Portfolios should cover a period of time, not just for a lesson or unit of study. Development of a portfolio should be ongoing. It is important for the portfolio not to become too voluminous. Care must then be given to determine what is salient and worthwhile to place into a portfolio.

Engel discusses the need for a new paradigm in the evaluation of pupil achievement; she wrote the following pertaining to portfolio use;

> Authenticity can be seen as consistency in time - between what is happening now and what is intended for the future. An action is authentic when aligned with its long term purposes - when one can look toward the future and see the connections between the means and the end. In assessment, authenticity implies the results can be trusted partly because the methods support long term purposes. Authenticity can be contrasted with expedience. The former is justified by a long term view; the latter by a short term perceived need.

What is contained in a portfolio represents authentic work and assessment in that the products and process come directly from the pupil within context of diverse learning opportunities. Test results would tend not to represent authentic work in that the test is given outside the framework of ongoing tasks and activities.

Tyler, Ralph (1949) raised four questions that are still very vital pertaining to teaching pupils. These are:

1. which objectives should pupils achieve?
2. which learning activities need to be provided so that pupils might achieve the stated objectives?
3. how should the subject matter be organized so that pupils might achieve more optimally?
4. how should pupils achievement be evaluated?

These are four questions that all teachers need to ask in planning and implementing instruction. Data for the portfolio might well come from answering these four questions. Certainly stated objectives are important in portfolio development. Learning activities provided pupils secure process and product results for the portfolio. Organization of related subject matter taught will be reflected as to what goes into the portfolio. Thus a separate subjects, a correlated approach, a fused curriculum, and/ or an interdisciplinary procedure will have its results inherent in the portfolio.

There are additional questions that need to be raised pertaining to portfolio content:

1. how many objectives in teaching and learning should stress knowledge, skills, or attitudes?

2. what kind of sequence is desired in the curriculum — a logical versus a psychological order of experiences for pupils?

3. how much stress should be placed upon a multimedia curriculum, including modern technology to aid pupil achievement?

4. which procedures should be used to appraise learner performance? The portfolio might well include diverse evaluation results, such as teacher written tests, norm and criterion referenced tests, discussions, products from learners, behavioral journals, diary and log entries, as well as teacher observation, among others, to notice pupils achievement.

When viewing all the questions raised above, there are answers which might well provide information for a portfolio. A problem then arises as to how thick a portfolio should be? There is no precise answer to this question. Selected guidelines need to be given, however.

Entries for a portfolio should be relevant and vital. Unimportant and irrelevant materials need to be culled. Portfolio content should reflect salient information that may be viewed and appraised by responsible people. The viewers then should be able to ascertain achievement in processes and products of a pupil. Where the learner is presently achieving and which sequential steps of further learning should be hypothesized from the portfolio content. It does take time for evaluators to assess the items in a portfolio. Careful appraisal is necessary of each portfolio. More than one competent, conscientious person should be involved in appraising a portfolio. Brown and Irby (1995) suggest that a major reason for portfolio development is to reflect upon improving teaching and learning. Educators today stress the importance of reflecting upon what has transpired in teach ıg so that improvement is an end result.

In Conclusion

The development and use of portfolios should be a way for pupils to reflect upon their progress and work toward higher achievement levels. There is a motivating ingredient in portfolio development and that is active involvement by learners in compiling a truly excellent device to inform others of personal progress in each curriculum area. The pupil is involved in a hands on approach in determining what should go into a portfolio and why. Wolf (1996) suggests teachers also develop their own portfolios. He wrote the following:

> Why this interest in teaching portfolios? Although portfolios can be time consuming to construct and cumbersome to review, they also capture the complexities of professional practices in ways that no other approach can. Not only are they an effective way to assess teaching quality, but they also provide teachers opportunities for self-reflection and collegial interactions based on documented episodes of their own teaching.
>
> Essentially, a teaching portfolio is a collection of information about a teacher's practice. It can include a variety of information, such as lesson plans, student assignments, teacher's written descriptions and videotapes of their instruction, and formal evaluations by supervisors...

A pupil's portfolio should compliment the teacher's portfolio. Both portfolios are developed to emphasize improved objectives, learning opportunities, and appraisal procedures. The end result should be that pupils achieve more optimally in each curriculum area.

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Each person lives in a world of science. The natural environment affects all of us. It operates in terms of scientific theories, principles, and laws. Pupils in the public school setting need to achieve relevant goals in science. These goals should be attainable, meaningful, and possess purpose for the learner. To improve the quality of life for each person, a problem solving approach should be emphasized in ongoing lessons and units in science. With problem solving, change occurs from what is to what should be in science.

Diverse schools of philosophical thought will be discussed and how each might relate to improve the science curriculum.

Realism in the Science Curriculum

A science teacher who is a realist emphasizes that one can know the real world, in whole or in part, as it truly is. The mind then does not modify or change what is being perceived. Tillman, Berofsky, and O' Connor (1971) wrote, "Most people when they think about the objects of perception, would say that they perceive a world of objects which is external to them and which exists independently of their perception of it. This view is called realism."

Since the external world is perceived the way it is in actuality, specific objective of instruction can be determined by scientists and science educators for pupils to achieve. Each objective must be relevant and is a part of the whole that can be known by the learner. Thus in geology, biology, chemistry, physics, and astronomy, among other academic disciplines, measurably stated objectives of instruction need to be emphasized in teaching and learning in the science curriculum. With quality learning opportunities selected by the science teacher, pupils either achieve or do not achieve the specific objective(s) as a result of instruction. Measuring pupil achievement in learning stresses what pupils have learned that was stated in each objective. Realists desire observable results in learning from pupils. The results are verifiable regardless of which teacher is appraising learner progress. The verification principle is very important to teachers of science who adhere to realism as a philosophy of instruction.

Skinner (1979) was a leading advocate in stressing precise objectives for pupil attainment. Reinforcement is emphasized to reward correct/ good responses in learning. Observable, measurable results are obtained from what pupils have achieved. Guesswork is not involved, but per cents, standard deviations, quartile deviations, grade equivalents, and percentile ranks emphasize how well each pupil is doing in the area of science instruction. Numerical results of pupil achievement in science is wanted by the realist teacher. Scores from tests; objective evaluations of science experiments and demonstrations performed by pupils; ratings given to learner performance as well as responses to questions, oral reports, port folios and related papers written in which interobserver reliability is in evidence, preseent data as to how well pupils are achieving. These procedures qualify as objective means of appraising learner progress.

Mager (1972) stressed the importance of writing objectives so they are operationalized. Objectives are then specific and clear to teachers, pupils, and other interested persons. Learning opportunities may be chosen and aligned with the stated objectives. Appraisal procedures used to determine pupil achievement are also aligned with the objectives. Quality validity and reliability are then in the offing. A pupil reveals if he/she attained or did not attain a stated objective. The realist science teacher wishes to know if pupils individually are or are not achieving objectives of instruction. The results may then be reported to parents in a very precise way.

Prior to instruction, the teachers may announce to pupils which objectives will be emphasized in the science lesson or unit. The pupil knows exactly what will be expected in terms of knowledge or skills to be obtained. The involved pupil should have more confidence in learning when realizing what the instructor's expectations are. The science teacher might desire to arrange the objectives in an ascending order of complexity. A logical sequence follows since the teacher sequences objectives in science for the pupil to achieve.

Advantages given for emphasizing realism as a philosophy of instruction are the following:

1. teachers may realize how successful they are in teaching since results form pupil learning are clear and observable.

2. objectives, learning activities, and evaluation procedures are interrelated in that the learning activities and the evaluation procedures must harmonize with the stated objectives. Thus, for example, it becomes easier to choose learning activities than otherwise would be the case due to the harmony needed between these activities and the stated objectives.

3. effective schools research states that pupils achieve better if there is a clear relationship between the learning activities and the evaluation procedures with that of the objectives of science instruction (Edmonds 1982).

Disadvantages given for emphasizing realism as a philosophy of education stress the fragmented knowledge that pupils may learn since each objective achieved emphasizes parts of a whole. The teacher controls the science curriculum since he/ she determines the objectives, learning opportunities, and evaluation procedures; pupils are not involved here in decision making. The products of instruction in science are emphasized, leaving little room for processes such as abstract thinking which is rather difficult to measure.

Experimentalism in the Science Curriculum

Experimentalists stress a problem solving approach in the curriculum. They emphasize that individuals cannot know the real world as it truly is. Individuals, however, obtain experiences of this reality. With experiences, changes occur in one's thinking and believing. A changing world makes for problematic situations. Problems need identification and solutions sought. In the science curriculum, pupils

with teacher guidance select a problem within an ongoing lesson or unit of study. The problem needs to be adequately delimited so that meaning and understanding is involved. An hypothesis is developed directly related to the stated problem. Information from a variety of sources is used by learners to arrive at a tentative solution. Experimentalists believe all knowledge to be tentative, not absolute.
The result might well involve changing and modifying the original hypotheses. The new hypothesis is then tried out in a concrete situation (Geiger 1955). Problem solving may be used in all curriculum areas and in life itself. Knowledge here is used to solve problems and is not an end in and of itself. The practical and the utilitarian are emphasized within the framework of problem solving: knowledge secured from a variety of sources has an application dimension. Knowledge then is useful to solve problems in a changing world, science included (Ediger 1995).

Experimentalists emphasize that school and society are one, not separate entities. Since groups in society select and solve problems, pupils in committees also need to be involved in cooperative learning stressing problem solving. School and society are one, not separate entities. Dewey (1915) is still very widely recognized as a leading advocate of experimentalism in teaching and learning. In integrating the learner with the self as well as with the societal arena, he advocated four characteristics of pupils which have wide implications for the teaching of science. These are that pupils possess the social impulse in that they desire to work together with others in the curriculum; the constructive impulse in which learners like to learn by doing, not being passive individuals; the investigative and experimentation inclination whereby pupils desire to learn by discovery rather than being told and lectured; and the creative or expressive impulse, rather than have rigid formal expectations for achievement.

Advantages given in emphasizing experimentalism as a philosophy of teaching science are the following:

1. pupil interest in science becomes paramount when they with

teacher assistance identify problem areas. Interest in learning makes for effort in achieving.

2. very young pupils in early primary grades may be involved in problem solving experiences (Ediger 1994).

3. problem solving is useful in all curriculum areas and in life itself when problems are selected and solutions sought.

Disadvantages of using experimentalism as a philosophy of education include problem selection being too difficult as well as problem solving may not be a favorite style and way of learning for a few pupils. Also motivation may be lacking for some pupils to identify and solve problems.

Idealism in the Science Curriculum

Idealists believe that one can receive ideas about the real world only. Thus one cannot know the real world as it truly is, independent of the observer. Mental development in idealism becomes of utmost importance since an idea centered world is in evidence. Mind is real and needs development. As a leading idealist still quoted widely presently, Horne (1932) stressed the importance of the use of reason and rational thought in arriving at truth. Concepts and generalizations or universals such as justice, truth, goodness, ethics, and beauty have always existed and can be discovered by human beings. These universals are a priori, to an idealist, in that they have existed prior to human experience.

A subject centered curriculum in science is of paramount importance. In science lessons and units of study, pupils should achieve vital concepts, and generalizations. Depth teaching is needed to cultivate the intellect in guiding pupils achievement in science. A multimedia approach in leaning is needed to assist pupils to achieve abstract ideas in science. The abstract to an idealist is superior to the concrete and semiconcrete in learning. The concrete and semiconcrete facets of learning in science are salient to the degree that learners attain the abstract such as vital facts, concepts, and generalizations in ongoing lessons and units of study. Since reading and writing, in particular, stress abstract learnings, they should not be minimized in the science curriculum.

To emphasize a subject centered curriculum as idealists recommend, an academically inclined teacher needs to teach in a scholarly way so that objectives stressing intellectual goals are attained by pupils. Blanchard (1964) wrote

> The aim of thought from its very beginning, we saw, was at understanding. To understand anything meant to apprehend it in a system that rendered it necessary. The ideal of complete understanding would be achieved only when the system that rendered it necessary was not a system that itself was fragmentary and therefore contingent , but one that was all- inclusive and so organized internally that every part was linked to every other by intelligible necessity.

Advantages given for emphasizing idealism as a philosophy of teaching science include the following:

1. pupils are to achieve significant subject matter. Idealism emphasizes the acquisition of vital content in science that pupils need to attain. Uses made of knowledge in science need to emphasize what is just to all, what is truthful, what is good in its application, what will truly stress ethical dimensions, and that which has beauty in its aesthetical areas.

2. many pupils may be motivated to learn when an academic approach to learn science is stressed. This might be especially appealing to the gifted and talented learners in science. All pupils need motivation to achieve and learn in science.

3. the abstract in idealism is preferred to the concrete and semiconcrete; relevant concepts, and generalizations, and other universals emphasize abstract goals in science teaching. Idealist advocate wholeness in knowledge, not fragmentation. Knowledge is related in all of its manifestations.

Disadvantages given for idealism as a philosophy in teaching and learning include minimizing a hands on approach in learning science since the focal point of teaching is to have pupils develop well intellectually; placing emphasis upon universals much more so than specifics — the latter is salient in pupils arriving at conclusions such as in science experiments; and integrating of knowledge to the point where science as a discipline is not as clearly defined as it might be. Idealists tend to stress that which goes beyond the five senses. Thus metaphysics and the a priori are salient to an idealist.

Quality sequence in science might be slighted when abstract phases of learning are more prized more highly than the concrete and semiconcrete. Most educators presently recommend a sequence of concrete, semiconcrete, to the abstract in teaching- learning situations. Quite similar in sequence, Bruner (1968) advocated using manipulative materials such as objects and items; followed by iconic materials such as audiovisual materials which are one step removed from the manipulative phase; and then symbolic activities which stresses the abstract including reading and writing.

Existentialism and the Science Curriculum

Existentialists believe that one exists first and then finds his/her purposes in life; there are no standards to guide human beings other than those developed by the human race. Most existentialists advocate that people are condemned to be free with no a priori standards in life. Individuals then make or break themselves due to the kind of society wanted. Each person chooses and makes choices continually. To be human is to choose. If a person permits the self to have someone else makes one's own decisions, then the individual ceases to be human.

Combs (1972) stresses that the way individuals perceive a situation will assist in determining how the individual will behave. Perception is unique to the individual. Each person decides upon what is true, judges what is good, and decides upon plans of action. The science curriculum then must provide opportunities for pupils individually to decide what to learn, that is the objectives of instruction. The pupil needs to be heavily involved in selecting learning opportunities as well as methods of determining progress. The teacher is a guide and encourages pupil learning. The teacher, however, does not lecture nor determine the science curriculum for the individual pupil. A learning centers approach in teaching science may then be emphasized. Here, there are an adequate number of centers with quality tasks for learners at each center. There needs to be more tasks than what a pupil can complete so that individual sequential choices may truly be made. A psychological, not logical, science curriculum is then in evidence. Each pupil may select tasks based on personal needs, interests, and purposes. The choice to be made is up to the individual pupil. If tasks do not meet personal needs of the involved learner, he/ she might plan with the teacher what has merit and value to the pupil. A contract system might also be implemented in which the pupil with teacher guidance selects tasks to put into a contract for completion. The learner himself/ herself is responsible for choices made. The individual perceives what is good and has quality. Knowledge is subjective, not objective to the existentialist. For example, in a values clarification session, the pupil determines what is moral in terms of uses made of science and technology; the teacher has a difficult position as a stimulator and of one who encourages pupil learning. Being humane in an absurd environment is a major goal for pupil achievement in existentialist thought and thinking.

The Psychology of Education

Principles of learning from the psychology of learning give direction to the science teacher in teaching-learning situations in ongoing lessons and units of study. Ediger (1994) lists the following criteria upon which educational psychologists agree should be followed by teachers;

1. meaningful learning experiences should be provided pupils in the curriculum.

2. interesting content and skills should be offered in lessons and units of study.

3. purpose needs to be established within pupils for learning.

4. quality sequence for pupil learning is a must.

5. rational balance among knowledge, skills, and attitudinal objectives is important in the instructional arena.

In Summary

Science teachers need to select tenets form the philosophy of education which stress pupils attaining vital content, abilities, and attitudes. In reviewing the different philosophies of education discussed in this paper, the following is salient from each philosophy:

1. clarity in objectives of science instruction, carefully selected, as recommended by realists. However, it is important to avoid fragmenting knowledge obtained by pupils.

2. problem solving procedures as recommended by experimentalist. Life in society emphasizes the importance of being able to solve personal and social problems.

3. major concepts and generalizations, as universals in science, advocated by idealists.

4. decision making opportunities in science as recommended by existentialists. Each person needs to learn to make decisions.

I believe that a problem solving philosophy encompasses the other three philosophies. I recommended problem solving as a major philosophy of education to emphasize in teaching science due to its relevance in the curriculum and in life itself. Problems abound and need solutions. Knowledge acquired then is instrumental or useful in problems to be solved which are selected by pupils with teacher guidance.

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