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ABSTRACT

This paper presents a fictitious debate among a group of science educators regarding the characteristics of an effective science curriculum. The debate explores the controversy between those science educators who have supported a basics approach to science teaching and the problem-solving approach advocated by educators behind reform efforts such as Project 2061, developed by the American Association for the Advancement of Science. A question and answer session with fictitious audience participants follows the presentations by the groups. Contains 12 references. (DDR)

RESTRUCTURING THE SCIENCE CURRICULUM

(A Public Debate)

by

Marlow Ediger

RESTRUCTURING THE SCIENCE CURRICULUM
(A Public Debate)

Leading science educators are seated in front of the auditorium; each is ready to present his/her recommendations pertaining to restructuring the science curriculum. A large audience of approximately 500 people are eager to hear each presentation in hopes of developing a quality, new science curriculum for Middle View Public Schools. The moderator has now completed introducing each distinguished science educator. Science educator #1 is ready to give a prepared report on the kind of science curriculum all pupils need to be functionally literate as well as achieve optimally in science.

Science Educator #1. For pupils to do well in science, we need to identify the basics in science. Unless this is done, pupils will be wavering and not know in what direction to go in learning. Once the basics have been chosen and implemented in instruction, pupils will have key facts, concepts, and generalizations to achieve. The science teacher might then arrange sequentially the objectives pupils are to attain. Why have pupils done poorly in the past in science achievement? Little effort has been put forth in selecting goals that are vital for pupils to achieve. These goals must represent basic knowledge and skills that pupils should learn. There is too much disagreement among science teachers as to what should be taught. If national goals, like Education 2000, as well as state mandated objectives have been carefully selected in science for pupils to achieve, through instruction we can have pupils reach the top in science achievement internationally. The National Governor's Conference identified six lofty goals (The National Education Goals Panel 1991); Goal #4 reads as follows: "By the Year 2000, US students will be first in the world in science and mathematics."

Also, there are basics locally that need to be selected in science for pupils to achieve. Lets have our committees busy studying which basics learners should achieve in science. These basics when agreed upon should provide the structure or core curriculum in science. For example, if pupils understand that fish, amphibians, reptiles, birds, and mammals are key ideas in understanding vertebrates, then content can be presented by the teacher which will assist pupils to relate the new with the old in subject matter as well as achieve additional objectives emphasizing the basics. If pupils learn that sedimentary, igneous, and metamorphic rocks represent three major classifications of rock, then new basic content will be that much easier to master. The new vital content is related to the basics which were mastered. I do not understand how any science teacher can teach without emphasizing the basics. I think our teaching will be much more effective if the basics are identified and taught to pupils. Why waste time teaching trivia in science? All too frequently that is what happens when educators and others have not selected basic content for all pupils to achieve. Former President Reagan and his Secretary of Education William Bennett continually stated that pupils should learn the basics.

Teaching science becomes more professional once the basics have been identified. A sower (the science teacher) that goes out to sow will then reap not thirty nor sixty fold, but one hundred fold. Why? Time spent in teaching science has been spent on the basics, not upon the irrelevant

Science educator #2. I agree with much that my friend here has presented, but it does no go far enough in emphasizing a quality science curriculum. What do I disagree with? We need to state the basics in measurable terms. After instruction, we can measure if a pupil has/ has not achieved the precise objective. Then too, the science teacher should state, prior to instruction, what is wanted from pupils in terms of learning from a lesson or unit of study. I see no reason for keeping pupils in the dark as to what they are to learn. This needs to be communicated in a clear, concise manner. Vagueness has no role to play in teaching- learning situations in science. Measurably stated objectives, announced clearly by the science teacher to pupils before learning opportunities are implemented, will assist learners to achieve as well as possible. Evaluation to determine pupil achievement needs to be aligned with the measurably stated objectives. Validity and reliability are then in evidence. Pupils achieve poorly in science if the evaluation techniques are not matched with the precise objectives. Pupils do not need to guess what they will be evaluated in; this was announced to pupils by the science teacher prior to instruction.

Measurably stated objectives on the national level (Education 2000) or the state level must be written with precision. The precise objectives emphasize what is vital and significant to learn. Never shirk in choosing objectives that are truly important in science. Locate evaluation techniques that measure what is stated inside each objective. It is the science teacher's role to teach toward the objective.
Why should precision be emphasized in writing objectives in science? The aligned evaluation techniques with the precise objectives of instruction will then be used to ascertain pupils progress in measurable terms. Results of pupil progress in science can then be clearly communicated to parents. Parents do not need to guess how well their offspring is doing in science achievement. Numerical results must be used to report pupil progress to parents. This is what parents accept and understand. If a pupil receives an A grade in science, this says nothing at all. Nor does it say anything about a pupil's achievement in science if the following categories appear on a report card — understands vital concepts, thinks creatively, solves problems, and has a good attitude. These are vague areas. If letter grades are given for each category, it fails to communicate how well a pupil is doing in science.

With measurably stated objectives and pupil results form testing, we get numerical results from each learner. A pupil then is on a certain percentile level, a specific standard deviation above or below the mean, and/or a particular quartile deviation. Numerical results communicate very clearly to parents in terms of their offspring's achievement in science. Effective Schools and Classrooms (1985) research results has shown time and again how well pupils do in science with the approaches in teaching and learning I have indicated.

Science educator #3. I disagree completely with my two predecessors as to the kind of science curriculum any school should desire. I have heard no mention made of the learner's interests and purposes in learning in either presentation. Are they not interested in the pupil who will be taught? Science is more than choosing the basics for pupils to acquire. It is also more than measuring and reporting to parents what the measurement results say. Both approaches can truly emphasize the insignificant and the unimportant to the parent and the pupil in the science curriculum. Thus we need a child centered curriculum in science. It is the pupil that will do the learning.

The late Carl Rogers, humanist educator, told of his starting public school as a child with great interests in moths. No one including the teacher could come close to Carl Roger's knowledge and interests in moths. There were children in school who made fun of these interests. The teacher, however, showed much interest in the young Carl Rogers and his purposes in learning. The teacher assisted him to increase his interests and goals in learning. Notice, the teacher helped the pupil build on his interests. The teacher did not lecture to the pupil on the basics nor in testing for progress in science learning. Dr. Rogers, as we all know, became a great psychologist and writer in educational psychology. His thesis was that the interests of pupils should provide the basis for all instruction. Good science teachers I have observed over the years find out what pupils are interested in and bring these interests into each lesson and unit taught. Learning stations with fascinating materials set up in the classroom by pupils and the teacher guide learners to become curious and develop an inward desire to learn. Pupils may then choose sequential tasks to complete from the learning stations, omitting those not possessing perceived purpose. Pupils are naturally curious in science as young learners. The curiosity seems to leave them as they move through the public school years. This lack of interest is due to teachers forcing the basics upon pupils as well as the continuous emphasis placed upon testing to find out what pupils have learned. Rather, we need to have stimulating materials in the classroom to encourage intrinsic motivation among pupils for learning in science. Thus a multimedia approach in teaching assists pupils to develop or remain curious in learning. But the emphasis must be upon the pupil with teacher guidance deciding upon what is of interest to the former.

If we permit much pupil input into the science curriculum, learners will bring many, many items of interest to school which stresses science. Achievement and progress in science will be spontaneous and intrinsic!

Science educator #4. I am shocked that all my predecessors who are supposed to be specialists in teaching science have left out the role of parents in developing the science curriculum. Research data indicates how important parents are in helping their children learn. Time and again, research indicates that if parents assist their children in learning, achievement continues to rise. Teachers, administrators, and supervisors must learn to work cooperatively with parents to increase pupil achievement. Too often, parents have been written off in being actively involved in the science curriculum. Why? Is it because we fear parental input into the curriculum? Or, do we feel parents have nothing to offer? This is indeed a sad situation. Parents are responsible for their children. They have been the first teachers of their offspring. Time and money has been invested by parents in their children. If parents lack parenting skills, is it not up to the schools to provide the needed knowledge and skills? Let us educate parents as needed. We need parental input into the science curriculum. Why? Parents need to support, be highly knowledgeable, and feel ownership in the science curriculum. Parents should come to visit the classroom where their children are being taught. Thy should have continuous contact with the teacher and school and not during the traditional parent- teacher conferences only. Coming to open house once a year does little to involve parents in the science curriculum of their children. Have we ever asked parents to serve as volunteers in our schools? Have parents ever been consulted as to which objectives their children should achieve in science? If we implement a needs assessment program to secure input from parents, we would then be empowering parental roles in curriculum development. We as educators need to get busy and carefully design a set of objectives in science for all parents to respond to. Parents may then rate on a five point scale the worth of each objective to be emphasized in teaching and learning. The results form this survey secure information in terms of what parents want to have emphasized in science lessons and units of study. Teachers and administrators must also respond to the survey. From the needs assessment program, we can obtain objectives that are truly worthwhile to emphasize in the classroom. When parents have input into developing the science curriculum, they will support their children more so in learning as well as support the goals of the school. Joyce Epstein (1995), a co- director of the Center on Families, Communities, and Children's Learning is a leading advocate in getting parents involved in their child's education. I agree wholeheartedly with her in having parents improve in their parenting skills, communicating with the schools, volunteering their services in school, learning to teach pupils at home with teacher guidance, and assisting in decisions made pertaining to their child's education and school curriculum. Those are excellent ways of improving the science curriculum!

Science educator #5. I cannot believe what I am hearing at this debate. All I have heard is teach the basics, have precise objectives for teaching, let the pupil decide what to learn, and permit parents to determine what should be taught in science. My friends, let us wake up to what science is all about. Let us wake up to what life itself is all about. In the science curriculum and in society, there are problems that need to be identified and solved. What is perceived to be the basics today may become outdated tomorrow. What can be measured may not represent that which is important to learn. What the child wishes to learn may be frivolous. What parents want to have emphasized in the science curriculum might well represent the irrelevant. Thus we need to stimulate pupils to identify and solve problems within ongoing lessons and units of study in science. Cooperatively, learners with teacher assistance need to choose problems to solve which are perceived by pupils as being significant. Significant problems make for interest in learning. Interest then makes for effort that pupils put forth in learning science. Why do we struggle to motivate pupils by forcing them to learn? We as science teachers can do much better than that with problem solving procedures used in teaching. The interest factor alone propels pupils in desiring to learn. Then too, problem solving will always be important regardless of the involved subject matter used. Subject matter may become outdated due to new research findings in science, but problem solving is here to stay. Let us not focus so much on the subject matter of science, but processes which pupils are to learn.

Once pupils have adequately delimited the problem in science, they may select activities which will obtain information directly related to the problem. Notice, we do not minimize subject matter acquisition, rather the subject matter is instrumental and used to solve problems. The subject matter must be critically evaluated by pupils to notice its accuracy, thoroughness, as well as its relevance in solving a problem. A hypothesis results which is tentative, not absolute. Additional subject matter needs to be attained to check the hypothesis. The subject matter comes from using a variety of media, including a hands on approach to learning. Thus science experiments and demonstrations are very important activities for pupils to gather information and to check hypotheses. Creative thinking is needed to guide pupils in achieving new ways of solving problems in science. Friends, I think we are missing the boat in the teaching of science unless problem solving is at the heart of the curriculum. Higher levels of cognition are emphasized here with process objectives stressed in science teaching.

Let us not forget the late John Dewey (1916), America's foremost and widely quoted educator, who continually emphasized problem solving as being the heart of the curriculum. Literature in the field of science pedagogy can assist teachers in emphasizing problem solving in teaching- learning situations. For example, the September 1994 issue of Science and Children, which I am holding up for you to see, has two nice articles on problem solving; these articles are "From Caterpillar to Butterfly" and "How Did Those Bugs Get in There?" Let us emphasize what is truly important in the science curriculum as well as what is salient in society and that is problem solving.

Science educator #6. I agree much with what my predecessor has just said. Processes such as problem solving are significant in science and yet the reasons are not holistic enough in terms of work that a scientist does. I recommend we observe what scientists do in a laboratory setting and then base our objectives on those observed processes. It is true that knowledge changes much and new subject matter in science is coming to us in astounding amounts. Thus we as science teachers must emphasize skills and processes in teaching that scientists recommend and do in a functional situation. There have been numerous studies made of the approaches scientists use in acquiring relevant facts, concepts, theories, principles, and laws. It is ridiculous for teachers to teach pupils and then use methodology that does not relate to the world of science and the work of scientists. The American Association for the Advancement of Science (1970) came out with a program of science teaching called "Science a Process Approach." Scientists were heavily involved in developing the curriculum. They listed objectives which pertain to how scientists work in a laboratory setting. I will state just a few of their objectives for pupils to attain. These are careful observation using the five senses, classifying information obtained, predicting what will happen such as in a science experiment, formulating hypotheses, interpreting data, and experimenting. The American Association for the Advancement of Science (1989) has again come up with objectives for pupils to attain in science; their newer publication is entitled Project 2061: Science for All Americans. Project 2061 emphasized a multimillion dollar investment in improving science curricula and approaches in teaching. Yes, the methods of science as used by scientists must be implemented in our classrooms. Why? That is what science teaching and learning is all about.

Science educator #7. I agree with much of what my two predecessors have said. I believe that a major element is missing here and that is to set high standards for all pupils to achieve in science. These standards need to be elevating and challenging to all pupils. Learners need to be grouped in a heterogeneous manner, not segregated based on ability. In a heterogeneously grouped classroom, pupils can learn from each other regardless of IQ and ability levels. All pupils then, regardless of ability and achievement levels, may receive sophisticated knowledge in science. Too frequently in the past, the slow learner received an inferior science education from teachers who were not too well motivated in teaching learners. We have eliminated those situations if tracking of pupils has been omitted completely. Tracking segregates and destroys interest in learning in science. Little is expected of pupils in the lower tracks. So, let us place pupils of mixed achievement levels in a classroom and have high expectations for all. Research states again and again that pupils in heterogeneously grouped classrooms achieve better than in a homogeneously grouped room of pupils. Tracking is undemocratic in that we have better teachers teaching science in homogeneously grouped classrooms of gifted pupils as compared to those classrooms having pupils of lesser talents. We can provide additional assistance to those pupils who find it difficult to keep up with the fastest learners in science.

Low achievement tends to come from lower teacher expectations for some pupils as compared to others. What chances do pupils have in the future when they are placed in the lower tracks of school? What chances do pupils have in the future when science teachers have low expectations for these learners today? Let us then move away from this negative practice of tracking pupils for instruction in science (Oakes, 1990).

Chairperson of the debate. I think that we can see rather wide disagreement among science educators as to what makes for a quality science curriculum in our public schools. The following points of view were given in moving from what is to what should be in the science curriculum:

1. A basics approach in determining what should be taught in science. These essentials provide a framework for what pupils are to learn in science. I well remember when pursuing the Ph D degree in science education how the professor stressed the eminent William Chandler Bagley"s (1934) strong emphasis upon teaching the basics in science as well as other curriculum areas. Advocates of the basics are very much with us as science educator number one indicated.

2. a measurably stated objectives approach whereby precise objectives would be chosen in science for pupils to attain. The late B.F.

Skinner (1979), Robert Mager (1972), and all behaviorists in psychology, advocate stating each objective in science in measurable terms. The teacher can then determine if pupils are/ are not successful in learning after instruction has taken place.

3. pupil involvement in developing the science curriculum. Here, the emphasis is upon pupils individually being involved in deciding upon objectives, learning opportunities, and evaluation procedures in science. The individual pupil decides upon working individually or within a committee. The task selected by the learner with teacher guidance may/ may not involve problem solving. Learning content for its own sake might also be salient, based on pupil interest. This should certainly empower the learner in the science curriculum.

4. parental involvement in helping to shape the science curriculum. In a democracy, we should not leave out those who will be affected by the decisions made by educators. Much research has and will continue to be conducted to show what affect parents have on their child's achievement. A needs assessment procedure may involve parents rather thoroughly in developing the science curriculum.

5. a problem solving science curriculum in which processes, not subject matter, receive primary emphasis. Problem solving truly is important. I well remember the first home my wife and I bought. There were so many problems to be solved such as how to finance the buying of the house, what kind of house to buy, what size of house to purchase, and the problems went on endlessly. One of my professors stated that his major problem in life so far had been who to marry. He briefly mentioned three major problems in the discussion. When studying all the changes in science content that is new and replaces the old, it is truly astonishing. Findings of the Hubbell telescope alone changes knowledge that we have about science! We do live in a fascinating era where new knowledge in science abounds. Problem solving as a process and skill seemingly remains highly important.

6. the methods of science emphasized in ongoing lessons and units in science. Since this debate focused upon what kind of a science curriculum to stress in our public schools, perhaps science educator #6

truly hit at the heart of our discussion. Certainly, the methods of science are central to the teaching of knowledge, skills, and attitudes.

7. high standards for pupils to attain in science so that optimal achievement is a goal for all. Tracking and segregating pupils need to be avoided in science. Certainly, we must stress democratic tenets in our classrooms. Now are there any questions from the audience?

Audience participant #1. I would like to address my question to Science educator #3. How can pupils know what is important to learn in science? They have not had the training and education that teachers have had. I just cannot see how we can have pupils follow their own interests and whims in science.

Science educator #3. If you noticed in my presentation, I stated that pupils with teacher guidance should make decisions on what the former is to learn. I did not leave the science teacher out of teaching and learning situations. The teacher is there to assist, guide, and help pupils. For example, if a contract system of instruction is used, the pupil decides upon which tasks to pursue within the contract he/she agreed to fulfill. Here, the the teacher encourages and enables the learner to pursue worthwhile goals in science. The pupil is rather heavily involved in developing the science curriculum because he/she will do the learning. If the teacher decides what pupils are to learn, the learner will turn off and out of what is being presented by the teacher. It is no wander that pupils fail to achieve well in science. Arthur Combs (1972), a well known educational psychologist, advocates pupils being involved in determining the objectives, learning opportunities, and evaluation procedures in the science curriculum. Otherwise, the teacher is at the center of the stage in deciding upon what pupils are to learn. Pupils lack purpose for achievement in these situations. It is the pupil, not the teacher, who is to do the learning.

Audience Participant #2. My question is directed to science educator #5. I am leery about pupils identifying questions and engaging in problem solving. I am a former teacher and my experiences have been that pupil attention span is too short to truly engage in the identification and solving of problems. This is a lengthy and drawn out process. I would rather have the teacher determine objectives, learning opportunities, and appraisal procedures for pupils in science. This goes back again to teachers being educated and trained to teach pupils in science. Our teachers are better educated than ever before with many possessing masters degrees and beyond in the teaching of science.

Science educator #5. It is no wonder that pupils, when adults, enter the world of work and cannot think well to meet requirements at the work place or at home if the science teacher teaches as you advocate. Teachers must assist pupils to engage in flexible steps of problem solving and that won't be easy. Easiest it is if the teacher lectures and spoon feeds pupils science facts in ongoing lessons in science. I cannot and will not buy that outdated approach in teaching. Lets have a learning environment, rich with materials, whereby pupils become curious and start selecting problems to solve. You know as well as I that life itself consists of identifying and solving problems, be it in science or in the larger societal arenas. The science curriculum must consist of what is truly important and that is for all pupils to be good problem solvers.

Audience participant #3. My question is directed to science educator #1. Do you have a list of the basics in science that pupils should learn? It sounds good to talk about the basics in science, but no one knows what these are. It seems to me if you have truly selected the basics for pupils to learn, you would be famous and maybe even wealthy, as far as society are concerned. All trivia in teaching could then be avoided in teaching; only what is salient would be emphasized.

Science educator #1. I detect a note of sarcasm in your question. Lets be serious in raising questions and making comments. We as science teachers must always view content in science with the intent that what is taught is truly essential for all pupils. I do this continuously and ask myself the question, "Is what I am preparing for teaching vital for pupil learning?" If it isn't, I cull that subject matter from my teaching. There is so much for pupils to learn in science; shouldn't teachers select what is basic for all pupils to learn? It is foolish to think otherwise.

Audience participant # 4. I wish to ask a question of science educator # 2. I feel that teaching becomes a joke when the measurably stated objectives are announced to pupils prior to teaching. We teach toward the precise objectives and then we evaluate to notice if pupils have achieved these same objectives. That certainly sounds mechanical as a method of teaching. Will pupils learn anything but specific facts under those conditions?

Science educator #2. I do not think that you understand basic assumptions of the measurably stated objectives movement. Clarity in stating objectives is necessary; otherwise we do not understand, as teachers, what we are teaching to pupils. Vagueness and uncertainty are there unless we state our objectives in measurable terms. We have no basis for choosing our learning activities in science unless the objectives are precise. How can we possibly evaluate unless teachers assess learner achievement against the stated objectives? Validity and reliability are possible in measurement if we align the measurement procedures with the stated objectives; otherwise our evaluation procedures miss the mark in deciding what pupils have learned.

Audience participant #5. I would like to direct my question to science educator #4. There are so many excellent statements of objectives in science for pupils to attain. Why should we waste time in having parents respond to a questionnaire in helping teachers determine what should be taught and what pupils should learn? Why can we not just enlist parents in helping to educate pupils as well as support the goals of education? I realize the importance of the home and school working together for the good of the offspring.

Science educator #4. I believe you are talking about indoctrinating parents to accept what has been worked out ahead of time for pupil learning. You need to realize the importance of democracy in the school and community setting. How can we leave an important group out of decision making in working on the science curriculum? There is so much research available that indicates how important parents are in their child's education. Let us then obtain the knowledge, interests, and purposes of parents in developing the best science curriculum possible for their children. Parents want the best for their offspring. They want their children to become proficient, knowledgeable, skillful, and possess good attitudes in science and in all curriculum areas. I agree here with parental input and definitely desire their assistance to guide optimal pupil achievement.

Audience participant #6. I wish to address my question to science educator#6. I get the impression when scientists emphasize objectives in science for children to achieve that the moral and feeling dimension of human being is omitted. We are all human beings and hopefully we can feel with others in times of happiness as well as despair. There are so many disasters due to nature such as floods, hurricanes, cyclones, and earthquakes, among others. Unless human beings assist and aid each other, we may not survive. Science has brought on such mass means of destroying each other such as in weapons of war.

Science educator #6. I appreciate your concerns about the uses made of science. Let us not confuse science as methods of approaching and securing objective subject matter or as a body of knowledge with uses made such as in technology. In your comments, you fail to mention all the improvements science has brought us such as in physical health, transportation, communication, and home conveniences, among others. The list truly is endless in terms of the good things that science has brought us through technology. I recommend that some time be devoted in our lessons and units in science to morality and ethics. Other curriculum areas may also stress the human dimension of individuals assisting each other in altruistic ways. However, we need to remember that pupils have many relevant objectives to achieve in science. Depth learning indicates that time on task is important so that each pupil achieves as much as possible in the science curriculum.

Chairperson. We have time for one more question from the audience and then our time will be up for this session.

Audience participant #7. My question is addressed to the last presenter. Your entire presentation emphasized setting high standards in science for all pupils to achieve in a heterogeneously grouped classroom. You also emphasized that all pupils in that classroom should achieve in a similar manner so that the sophisticated science knowledge is available to all, not just the talented and gifted. Don't you respect individual differences in the classroom whereby learners are different in achievement in science? The gifted and talented need a more rigorous science curriculum with higher academic standards than do the slow and average achievers. We need to guide all pupils to attain optimally. Individual differences among learners exist including full inclusion of the handicapped in the classroom. With diversity in the classroom, we certainly need a multicultural science curriculum. The February 1995 issue of the Science Teacher is devoted entirely to multi-cultural education in science. Each person in the audience should read that issue.

Audience participant #7. I do not agree on segregating pupils based on ability levels. Democratic tenets say that we must have all pupils obtain sophisticated knowledge in science so that they are not hindered in achievement as compared to those possessing increased ability levels. We have under estimated the achievement of what former were called the slow learners. They can learn along with others in a mixed ability level of pupils in teaching science. With ample opportunities in cooperative learning, pupils of different ability levels can assist each other in learning. They may also learn to work harmoniously with other pupils in cooperative learning. Therefore, let us avoid segregating pupils in the classroom.

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