DOCUMENT RESUME

ED 253 415

SE 045 380

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TITLE Philosophy of Microcomputer Use in the Mathematics Curriculum.
PUB DATE [84]
NOTE 29p.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052) -- Information Analyses (070)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Computer Oriented Programs; Computer Simulation; Computer Software; Drills (Practice); *Educational Philosophy; Elementary Secondary Education; Mathematics Curriculum; *Mathematics Education; *Mathematics Instruction; *Microcomputers; Problem Solving; *Programed Instruction; Remedial Instruction; Word Processing; Workshops

ABSTRACT

How microcomputers are to be utilized in on-going mathematics instruction is discussed. In the first section, the ideas of Skinner are considered in relation to microcomputer use. How computer-assisted instruction would appear when Skinner's programmed learning suggestions are followed is described, and other points of his philosophical beliefs are discussed. In the next section, the use of microcomputers for drill and practice is noted, with questions raised. The use of word processing in the mathematics curriculum and in particular in problem solving is next discussed. This leads to a discussion of the broader meaning of problem solving. The fifth section considers remedial work, with characteristics of useful software listed. Next, the usefulness of simulations is discussed, followed by sections on tutorial concepts, correlating mathematics with other curricular areas, computer managed instruction, and computer literacy. In-service education with computers is the subject of the final section, emphasizing teacher workshops. (MNS)

Philosophy of Microcomputer Use in the Mathematics Curriculum

by

Dr. Marlow Ediger

PHILOSOPHY OF MICROCOMPUTER USE IN THE MATHEMATICS CURRICULUM

There are diverse beliefs that provide guidance and direction to choices made in life. Beliefs adhered to can be stated in terms of philosophical categories. It is significant for teachers, supervisors, and administrators to study and analyze diverse schools of thought in the philosophy of education. Thus, educators in the school and class setting may experiment with diverse practices in education utilizing different philosophies of education. A thorough grounding in each philosophy may well provide increased recommendable alternatives in teaching and learning situations. How microcomputers are to be utilized in ongoing units and lessons in mathematics is based upon varied strands of thought in the philosophical arena.

B.F. Skinner and Microcomputer Use

B.F. Skinner (1904-) is a strong advocate of programmed learning. To develop quality programs, Dr. Skinner would recommend that pupils achieve and progress in small steps. Computer Assisted Instruction (CAI) is then in evidence. Thus, a small amount of content is read on a monitor or screen. A test item may then follow in which the learner responds to a completion or multiple choice item, based on previous content read. If a student is correct in responding to the item, "that's excellent" or its equivalent may appear on the monitor as reinforcement. If an incorrect response was given, the learner may be given a second chance to respond with the words "Try again" appearing on the screen. If the involved student has again punched in wrong commands on the microcomputer terminal, the correct answer to the completion or multiple choice item is provided on the monitor. In linear programming, the successful student and the incorrect responder both are then ready for the next sequential item to be learned. Each has received feedback as to correctness of responses given.

The same/similar sequence follows, read a small bit of information on the monitor, respond to a test item directly related to what was read, and experience reinforcement with "that's excellent", or similar rewards if the student responded correctly. Or, with an erroneous answer typed in as a command in the microcomputer, the student is asked to "Try again". If the pupil still responds incorrectly on the second try, he/she may then see the correct answer on the screen and also be ready for the next sequential programmed item. Should the student have responded correctly on the second attempt, he/she would also experience reinforcement with "Good" or similar rewards appearing on the monitor. Continuous programmed items may follow the above named procedure, such as read, respond, and check.

Having pupils progress in small sequential steps emphasizes programmed learning. Additional beliefs involving programmed learning include the following:

1. a high rate of success by students is in evidence in completing a program. In quality software using a microcomputer, learners should be successful in at least ninety per cent of the items.

2. repetition assists students in sequential items in a program. Thus to store items in Long Term Memory (LTM), built in drill is inherent in Computer Assisted Instruction (CAI). Otherwise Short Term Memory (STM) is being emphasized.

3. reinforcement strengthens the stimulus (S) and the response (R) in S-R theory of learning.

4. programmers order content in software or book form. Any subject matter can be broken down into component parts. Thus, in the arithmetic curriculum involving addition, subtraction, multiplication, and division, a subject matter specialist must order each step of student learning. Field testing aids in adding a specific item or more in sequence when appraising a program to notice its effectiveness in ordering continuous progress of learners.

5. each response given by an involved student is measurable and observable. Internal reaction within a student are not important.

6. continuous feedback is given to each learner using programmed materials at a terminal. After, a learner reads an item (S for stimulus) appearing on on the monitor, he/she types in a response (R). Feedback is then provided on the screen in terms of the correctness or incorrectness of the response given by the learner.

In terms of a psychology of learning, programmed instruction emphasizes a logical sequence. Thus, the programmer orders sequential items in programmed materials. Student—teacher planning is not involved in sequencing learnings for the former to acquire. Rather heavy pupil involvement in achieving sequence in learning emphasizes a psychological not a logical curriculum.

Skinner[1] wrote:

> The "mechanizing of education" has been taken literally in the sense of doing by machine what was formerly done by people. Some of the so-called computer-based teaching machines are designed simply to duplicate the behavior of teachers. To automate education with mechanical teachers is like automating banking with mechanical tellers and bookkeepers. What is needed in both cases is an analysis of the functions to be served, followed by the design of appropriate equipment. Nothing we now know about the learning process calls for very elaborate instrumentation.
>
> Educational specialists have added to the confusion by trying to assimilate the principles upon which teaching machines are based to older theories of learning and teaching.
>
> In the broadest sense, teaching machines are simply devices which make it possible to apply our technical knowledge of human behavior to the practical field of education. Teaching is the expediting of learning. Students learn without teaching, but the teacher arranges conditions under which they learn more rapidly and effectively. In recent years, the experimental analysis of behavior has revealed many new facts about relevant conditions. The growing effectiveness of an experimental analysis is still not widely recognized, even within the behavioral sciences themselves, but the implications of some of its achievements for education can no longer be ignored.
>
> An important condition is the relation between behavior and its consequences; learning occurs when behavior is "reinforced". The power of reinforcement is not easily appreciated by those who have not had first-hand experience in its use or have not at least seen some sort of experimental demonstration. Extensive changes in behavior can be brought about by arranging so-called contingencies of reinforcement. Various kinds of contingencies are concealed in the teacher's discussions with his students, in the books he gives them to read, in the charts and other materials he shows them, in the questions he asks them, and in the comments he makes on their answers. An experimental analysis clarifies these contingencies and suggests many imp rovements.

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[1] B.F. Skinner, "Reflections on a Decade of Teaching Machines, "Teacher's College Record, November, 1962, page 127.

Reinforcement theory is a central concept in the thinking of Dr. Skinner. A correct response by a student to a programmed item reinforces or strengthens the possibilities of that learner in responding correctly in future times to that same item. Thus, the stimulus (S) and the response (R) in the stimulus and the response are connected or associated in terms of future student responses. The reinforcement is specific and not general. The specific connection then occurs only to the programmed item appearing on the monitor. It is not general since attitudes, purposes, and interests in one situation do not transfer to another situation.

In fact Dr. Skinner emphasizes only that items that are measurable or observable are important in education. For example, if the following number pairs appear sequentially on a screen: 5+6= , 6+5= , 7+5= , 5+7= , 6+6= , it is measurable if a student responded correctly or incorrectly to each specific addition fact. There is no leeway for interpretation what the exact value of each sum is to the above ordered items. In the case of attitudes, one cannot measure with precision if it is right or wrong. The same holds true for purposes, and interests. Can any measurement specialist say that a student has as one hundred percent, fifty percent, or any other percent of possessing good or negative purposes? The answer would definitely be in the negative. Attitudes, purposes, and interests are internal and not measurable in terms of being correct or incorrect.

A learner who responds correctly to 5+6= , 6+5= , 7+5= , 5+7= , and 6+6= in successive programmed items experiences operant conditioning. Thus, in being correct to answers given, the response is reinforced. Operant conditioning emphasizes reinforcing or strengthening the response. A learner may then continually respond correctly to the same number pair or pairs.

Morris and Pai[2] wrote:

As we have seen, Skinner explains the learning of all voluntary actions in terms of operant conditioning. In other words, our voluntary responses occur because they are reinforced. Even verbal behavior such as giving a lecture on behaviorism and the technology of teaching is thought of as behavior reinforced through the mediation of others who, as listeners, respond to the speaker in such a way as to strengthen the lecturer's behavior. And because of his antitheoretical bias, Skinner is unwilling to deal with the question, "Why do reinforcers reinforce?" other than to say that they do in fact increase the probability of a response. There is little doubt that in any analysis of animal behavior or simple human responses this reinforcement view is adequate. Moreover, if all our educational and instructional objectives dealt with relatively simple responses, Skinner's operant conditioning might be sufficient. But our instructional objectives have to do with complex skills, attitudes, and beliefs that cannot be expressed completely in terms of directly observable responses.

Questions about the child's purpose and intention almost always arise in dealing with teaching-learning situations. Our own purposes and intentions as well as our interpretation of other people's aspirations and motives affect our conduct. For example, if you are hit by a baseball, your reaction to the incident depends upon how you understand the intentions of the person who threw the ball. If you decide that the ball accidentally hit you, you might walk away, but if you conclude that the ball was deliberately thrown at you, you might take a considerable different course of action. We are not, of course, suggesting that there is a world of intentions that is distinct from the world of physical events. But we are suggesting that Skinner's reinforcement language cannot adequately deal with the kinds of phenomena usually called mental.

Skinner[3] wrote:

The literature of freedom has encouraged escape from attack upon all controllers. It has done so by making any indication of control aversive. Those who manipulate human behavior are said to be evil men, necessarily bent on exploitation. Control is clearly the opposite of freedom, and if freedom is good, control must be bad. What is overlooked is control which does not have aversive consequences at any time. Many social practices essential to the welfare of the species involve the control of one person by another, and no one can suppress them who has any concern for human achievements. We shall see later that in order to maintain the position that all control is wrong, it has been necessary to disguise or conceal the nature of useful practices, to prefer weak practices just because they can be disguised or concealed, and—a most extraordinary result indeed!—to perpetuate punitive measures.

The problem is to free men, not from control, but from certain kinds of control, and it can be solved only if our analysis takes all consequences into account. How people feel about control, before or after the literature of freedom has worked on their feelings, does not lead to useful distinction.

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[2]Van Cleve Morris and Young Pai. Philosophy and the American School. Boston: Hought-Mifflin Company, 1976, pages 334 and 335

[3]B.F. Skinner, "Freedom Through Control, "Taking Sides: Clashing Views on Controversial Educational Issues. Guilford, Connecticut: The Dushkin Publishing Group, Inc. 1989, pages 43 and 44.

B.F. Skinner in terms of philosophical beliefs would be classified as a scientific realist. A realist believes that he/she can know the real world in whole or in part as it truly is. Thus, the individual, according to realism as a philosophy of education, receives a replica or duplicate of the real world. The viewer does not receive ideas only of the natural and social environment, but is able to see reality and realness. The realist goes beyond being capable of experiencing what exists and is. He/she is able to receive stimuli that presents the environment in its actuality.

Dr. Skinner advocates that observable results and not what is internal is vital to notice in terms of student achievement and progress. The products or measurable results are significant for teachers to notice pertaining to pupil achievement. What happens internally along the way to guide students in achieving the behaviorally stated, measurable results is not important. In other words, one cannot know what happens within the individual when learning takes place. Rather the ends or precise objectives point the way in terms of what pupils should learn. Whether or not students individually have attained the desired ends is measurable. The observer, whether teacher or pupil, can know if the latter has or has not been successful in goal attainment. The interests, purposes, meanings, and goals of pupils is not observable in a precise way. These items exist within the student and therefore are unobservable.

Since Dr. Skinner takes note only of what is observable and not internal, a major method of science is being utilized in studying human behavior. Scientific methodology emphasizes that which is objective and can be observed. Subjectivity needs to be eliminated. What is objective can also be recorded and measured. Thus, quantifiable results are in evidence. The subject matter of diverse academic disciplines in science stresses that which can be quantified.

Observers whoever they may be in scientific endeavors emphasize precision and measurability. If something exists, a certain amount of that existence is in evidence. Since there is evidence of something existing, that something can definitely be measured. The observer then in realism, as a philosophy of education, can observe what really and truly is. That which is can be stated in measurable terms.

A true realist believes that the natural and social environment can be known as it is. Whatever is would emphasize a definite amount or quantity. Anything that can be known as it truly is emphasizes the concept of quantification.

Opposite of realism might well be the following:

1. truth is in the eye of the beholder. Rather, what exists is objective to any observing being. The observations would agree with precision regardless of who the trained observers are.

2. to be is to be perceived by a person or being. Instead, what exists is objective and independent of an human observer.

3. the human being can only know what is experienced. The experience(s) must be qualified with the terms of observability and quantification. Otherwise, persons individually may disagree among themselves in terms of what has been experienced and thus subjectivity as a concept is definitely in evidence.

4. faith emphasizes that which is good. Faith is internal and lacks evidence. Observation and objective quantification of results emphasizes that which is true regardless of involved observers.

5. ideas alone, and not the natural/social environment as it truly is, in and of themselves, provide reliable indicators of subject matter. Ideas are internal and do not represent objectivity in the real world.

Castell and Borchert[4] wrote:

> ...B.F. Skinner published his <u>Beyond Human Freedom and Dignity</u> in 1971. He calls upon humankind to discard the notion of an "autonomous inner man" or "soul" which is the source of all our allegedly free acts. If the science of human behavior, says Skinner is to make any significant progress, it must adopt the deterministic model and probe the causes of human behavior in the environment and genetic endowment of persons. In abandoning the "autonomous inner man," Skinner removes the legitimacy for praising and blaming people for their actions. After all, how can you justifiably praise or blame someone for doing something that hereditary and environmental factors forced him or her to do? Responsibility is transferred from "autonomous inner man" to heredity and environment, and the human is seen as the manipulated pawn of forces beyond his or her control...

[4] Alburey Castell and Donald M. Borchert. An Introduction to Modern Philosophy. New York: The Macmillan Company, 1983, page 77.

Microcomputer Use with Drill and Practice

There are diverse schools of thought in terms of what microcomputers can do in the mathematics arena. Thus one use of microcomputers is to emphasize drill and practice. A teacher can stress drill, for example, in the use of traditional flash cards to aid students in retaining learnings in answer to basic addition, subtraction, multiplication, and division facts. Or, drill can be emphasized within the confines of activities in basal mathematics textbooks. The manual attached to the textbook can provide the teacher with suggestions pertaining to teaching the basic four operations. Drill can also be emphasized in using mimeographed worksheets. Content from the flash cards, mathematics textbook, and worksheets should aid students to achieve worthwhile objectives. Other activities emphasizing drill could be with the use of games made by the teacher or purchased commercially by the school system. There are problems or questions involved when utilizing microcomputers in drill and practice activities. These include the following:

1. Should microcomputers provide an additional means of emphasizing drill and practice, or should their use involve only those activities which do not duplicate selected methodology, e.g. use of flashcards, textbooks, worksheets, and games.

2. Are there an adequate number of microcomputers so that <u>all</u> students may experience worthwhile drill and practice activities?

3. Does available software truly provide sequential learnings for involved students or has the software not been field tested adequately to provide necessary ordered tasks?

4. Does available software relate directly to the ongoing mathematics unit presently being taught? Or are available software totally unrelated to units being taught in the mathematics curriculum?

5. Does the software truly provide quality sequential steps in learning or is it entertaining largely or only?

6. Are the interests of students being met within the framework of software being utilized?

7. Does the involved student perceive purpose in ongoing programmed learning tasks involving drill and practice?

8. Do pupils individually experience sequential learnings or does the sequence reside within the minds of the authors or programmers?

9. Are the software programs challenging and stimulating to learners?

10. Can teachers adequately monitor and supervise students at each terminal when responding to programmed items?

It is not easy to match software programmed experiences with the capabilities and capacities presented by learners who will interact with the microcomputer. Precision and exactness may not be in evidence when matching software with the involved student. Certainly, the program involving drill and practice must be fused or integrated with the participating student.

Using a Word Processor

Utilizing a word processor in the mathematics curriculum is quite different from drill and practice within the microcomputer framework. In many ways, the student manages and controls word processor usage rather than responding passively in drill and practice. Thus, in drill and practice a programmer has ordered or sequenced items for student response. The stimulus or stimuli (S) comes from the programmer. The response (R) to each programmed item comes from the student. Reinforcement when responding correctly in S→R theory of learning is sequenced by the programmer. If a student then responds correctly to an item, a smiley face may appear on the screen. That same smiley face might appear on the monitor and screen again and again as reinforcement (reward) for each correct response. The response (R) is rewarded in operant conditioning. Hopefully the learner will respond correctly again and again. To avoid repetition a programmer may utilize diverse means of reinforcement. Thus, in addition to a smiley face, words such as "that's right", "you're doing well", "tremendous", and other reinforcers are used as reinforcement.

A word processor operates quite differently in its philosophical emphasis. The student types in commands on the keyboard at the terminal as is true of programmed learning. However, ideally, the subject matter typed in to the word processor comes from the student. Or, if the pupil is young and cannot type the subject matter into the keyboard, the teacher may type the dictated ideas or dictation from the learner.

Which content from students may be typed and shown on the monitor or screen of a word processor? An open-ended philosophy is in evidence here. Thus, a student may develop story or word problems in mathematics in a creative manner. Problem solving may be emphasized involving higher levels of cognition. The problems may emphasize analyzing. For example, irrelevant content may be inherent in the word problem and the student needs to separate the relevant from the irrelevant in order to solve the story or word problem correctly. The cognitive level of application can be emphasized in that students need to utilize previously acquired knowledge to solve a problem. Or, the cognitive level of synthesis may be vital in solving the problem creatively developed by the student in using the word processor. To synthesize, students could brainstorm approaches in solving the problem. To synthesize means to put together in a gestalt or whole to solve problems. A holistic emphasis then is involved when brainstorming is involved in problem solving.

The cognitive level of evaluation may also be stressed when story or word problems developed by students are typed into the word processor. Each problem then is appraised in terms of clarity, meaning, complexity, and mechanical correctness, such as spelling, usage, and sequence of ideas.

Use of a word processor can eliminate much of the drudgery of rewriting and retyping typical of traditional approaches in using longhand and typewriters. Thus, any spelling error appearing on the monitor or screen can quickly be corrected using the appropriate keys on the terminal. If vital content is left out in what appears on the screen, insertions can also be made by typing in the correct commands.

After all needed corrections appearing on the screen have been made, the printer of the word processor can print all the hard copies of the arithmetic problems needed. These papers should have all errors taken out prior to being printed. Students then with teacher guidance may solve each problem. The student who provided mathematics problems in the hard copy, no doubt, will want to exchange a paper developed by a different student. A quality mathematics curriculum can emphasize students being involved in writing their own story or word problems.

In utilizing a word processor, the student

1. controls the content being typed into a machine. The programmer does not control the student in a step by step approach in learning as was true of drill and practice programs.

2. practices writing (typing) subject matter. Mathematics is the third of the three r's—reading, writing, and arithmatic. Reading proficiency is a vital skill in the mathematics curriculum.

3. engages in proofreading and ~~correct~~ content appearing on the screen or monitor.

4. reads subject matter that has been composed personally. The learner also reads story or word problems developed by other learners when working to solve these problems.

Problem Solving in Society

Solving real problems in society involving mathematics can be quite different from story or word problems. There are mathematics educators who believe that school should not be separated from society. The mathematics teacher needs to guide students to identify and solve practical problems in the societal arena. Which are selected utilitarian problematic areas for students to develop needed solutions?

1. unit pricing of several brands of cereal, flour, and soap. Students need to ascertain which brand would be the best buy, all other variables kept constant.

2. keeping a checkbook balance accurately.

3. being able to check personal checks written with the monthly computerized bank statement from the local bank. The student then needs to

check personal cor :eled checks written with the monthly statement issued by the bank to show checkbook blance.

4. computing the total cost of items ordered from a supply house or purchased from a local store.

5. helping parents compute federal, state, and local income taxes.

6. learning from parents pertaining to interest costs involved in buying a home, car, or other item on installment payments.

The above, among others, represent actual situations in life in which problem solving is involved. Which require the utilization of a microcomputer may well provide content for a debate. Certainly, a microcomputer should not be utilized in which other procedures may be quicker and more efficient in problem solving, such as the hand held calculator.

Problem solving as a philosophy of teaching and learning emphasizes that students

1. identify relevant and worthwhile problems. The identified problems are life-like and real. Ideally, they come from perplexing situations in society. School and society are not to be segregated entities. Rather, what is vital in mathematics usage in the real world of society needs emphasis in the school curriculum.

2. gather data in answer to the problem. Software and microcomputer usage may well have in memory vital data which can provide the needed information upon retrieval. The data must be significant and directly related to the identified problem.

3. develop one or more hypotheses in answer to the problem. Adequate data or content needs to be in the offing to develop a viable hypothesis.

4. test the stated hypothesis or hypotheses. If the hypothesis holds up when it is tested, it remains as originally stated.

5. revise the hypothesis if results indicate it necessary to do so. The hypothesis as originally stated may also need to be refuted if evidence warrants.

Problem solving philosophies deemphasize

1. precise, measurable objectives predetermined for students to achieve. Students are left out of planning goals to achieve personally, if the goals, measurably stated, have been decided upon prior to their introduction into the classroom setting.

2. the use of mathematics textbooks outside the framework of assisting students to solve problems in the real world of society.

3. teachers and supervisors developing the scope and sequence of the mathematics curriculum with little or no input from students.

4. students being passive recipients of knowledge received from the lecture method.

5. individual endeavors in mathematics. Rather, in society, groups and committees identify and solve real, not textbook nor imaginary problems. Thus, cooperative problem solving needs to be emphasized in the mathematics curriculum.

Remedial Work and the Microcopmuter

The concept of remedial work emphasizes diagnosis. Inherent in diagnosis is noticing by the mathematics teacher specific kinds of errors any single student makes. Errors made by a learner must be consistent for any single type of weakness. A student may make an error only once or twice pertaining to a specific kind of mistake. This would not entail remedial work emphasis to correct. Rather, a certain type or kind of error needs to be made consistently by a student and thus stress the concept of remedial work.

Software stressing remedial work in mathematics must

1. start with where the student is presently. If the content in the software is too difficult for the student, frustration, no doubt, will be an end result. If it is too easy, the concepts of drill and practice will be in evidence. If a learner, for example, is ready to find the area of a circle and cannot exhibit needed skills or knowledge to perform the computation, then the program should begin with the students' present level of achievement and progress in small sequential steps thereafter.

2. be user friendly to the learner. If a student then is asked to find the area of a circle pictured on the screen of the microcomputer and no mid-point is shown in that circle, the chances are that excessive time will be spent by the involved learner in accurately determining the length of the radius. Or if the learner needs to add an extra step to advance to the next programmed item, the mechanical steps involved in using the microcomputer may be frustrating indeed. For example, a student has responded correctly to a programmed remedial item, then presses the return key and the space key in sequence for the next sequential learning; certainly pressing the space key should not be in the program. This makes for an additional step in the mechanical operation of the software which is unnecessary. Rather, the student should focus upon sequential learnings which are vital, significant, and relevant.

3. reflect accuracy and correctness. Thus, in having students find the area of a circle, software content showing one or more circles should emphasize accuracy in this geometrical concept. Ovals and ellipses shown on the screen are not circles. Certainly, content in software needs to emphasize the concept of correctness. Otherwise, students may well develop inaccurate concepts and generalizations.

4. emphasize proper order in its contents. Students cannot achieve optimally unless the new learnings are definitely related to what has been acquired previously. Software that has not been field tested may have ordered steps of learning which are too far apart. Thus, the involved student cannot attain the next sequential content in programmed learning due to inappropriate sequence.

5. stress frequent responses of the participating student. Too frequently, the student may need to read an excessive amount of subject matter before making a response. With fewer responses made by the learner, feedbacks will be rather minimal. Feedback is provided by the programmer only in terms of each response provided by the student using the keyboard on the microcomputer. Frequent interaction of the student with content in the software is highly recommendable.

Roe[5] listed the following criteria to be utilized in selecting software:

> If teachers who are not involved in the selection process are expected to use computers provided by their schools, they need to know how to approach the task. The first step is most important: teachers must obtain appropriate software (instructional programs) to use on the particular microcomputer systems available. The software is the heart of the CAI system. Good quality software can provide quality instruction; poor software will provide poor instruction. Therefore, teachers must become evaluators of the programs available for use with their classes. Just as they must examine all supplementary materials they use for quality, they must examine software with these questions in mind:
>
> 1. Is the material instructionally sound? Does it present accurate information in a logical sequence with an appropriate amount of pupil interaction? Do its reinforcement patterns encourage correct responses or incorrect ones?
>
> 2. Is the program easy for the learner to use? Are there clear instructions at all points in the program? Is there a way for students to receive help when it is needed?
>
> 3. Does use of the program accomplish something that is needed in my classroom? (No one should buy a program just because it is available!)

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[5] Betty D. Roe, "Computers in the Schools: Here to Stay", Educators Forum, Fall, 1984, page 9.

Simulations in the Mathematics Curriculum

Simulations may well emphasize higher levels of cognition such as applications of previously acquired learnings, critical thinking, creative thinking, as well as problem solving. Simulated content attempts to provide reality based situations to learner. However, within the framework of these reality based situations, students experience low risk experiences. Thus, the concept of failure is greatly minimized in simulation programs.

Dennis and Kansky[6] wrote the following pertaining evaluating computer use:

1. In what ways can a computer participate in instruction?

2. What educationally important things could a school do with the aid of computers that it could not do without them.

3. What aspects of instruction can be performed significantly better with the aid of computers?

4. What problems can be expected from using computers in the ways identified?

5. Is it likely that we really will do any of the things that computers will make possible?

Clearly, we need to think a bit about how computers might be used in instruction.

Instructional uses of computers can be sorted into two piles. In one case, the uses involve the computer itself as the object of instruction; the focus is upon teaching about computers. In the other pile are those uses in which the computer is a medium (or tool) of instruction; these uses focus upon teaching with a computer.

A worthwhile tool of instruction using microcomputers is in the simulation arena. In simulations, students

1. participate in role playing. Each role needs to be as realistic as possible.

2. make decisions and choices. The involved learner interacts much with the microcomputer.

3. receive feedback or information pertaining to choices made.

[6]J. Richard Dennis and Richard J. Kansky. Instructional Computing. Glenview, Illinois: Scott, Foresman and Company, 1984, page 9.

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4. revise their frame of reference in the making of new decisions after receiving feedback.

5. engage in higher levels of cognition, rather than the recall level.

6. apply knowledge that has been acquired previously.

7. analyze a situation prior to the making of a new decision.

8. bring background knowledge when synthesizing content to make choices.

9. evaluate feedback received from choices made.

10. must comprehend content within the framework of each program.

Students must have ample opportunities to interact and respond when utilizing simulated programs. The student needs to be an active responder not a passive recipient of subject matter. Directions for each simulation need to be clear and understandable. Opportunities need to be in evidence for students to Exit from the simulation program. Also, if the learner wishes, he/she can start all over again. A simulation that is partially completed by learners should be stored and retrievable for the next class session in mathematics. The teacher's guide for the simulation needs to have readiness learning activities for students. The content in the guide needs to be meaningful for the mathematics teacher.

Teachers need to actually work through diverse simulations in mathematics to appraise if the content is based on the needs, interests, and purposes of students in the classroom setting. Sell Lemonade (profits and losses are computed in this simulation) and Change (students compute change and choose involved coins) are examples of computerized simulations in mathematics.

Tutorial Concepts and Programmed Learning

So far the writer has discussed drill and practice, use of the word processor, problem solving, remedial work, and simulations in the mathematics curriculum using microcomputers. What about new programmed learnings for students to achieve in ongoing units in the mathematics curriculum? These objectives may relate to content contained in the basal mathematics textbook(s) presently being utilized. Thus, in a step by step ascending order of complexity sequence, students may achieve new learnings. Students need to experience a high degree of success in each sequential step of learning. Pilot studies involving student use of the software have been made to take out weaknesses in between any two steps in sequence in the program. Quality attitudes and feelings can be developed in ongoing experiences if students individually experience success. Debugging or taking out the weaknesses of any single program is important.

For each correct response made by a student to a programmed item, appropriate reinforcement or reward needs to be in evidence whether it be a smiley face, "that's tremendous", or "good work". The rewards should be varied and not repetitious.

To respond to a programmed item, the concept of user friendly is always important. Thus, on the keyboard pupils should not need to type in lengthy answers in which correct spelling of complex words is involved. Errors in typing the correct spelling of mathematics terms can be made even by a good speller. A microcomputer will not accept incorrect spelling of words. Certainly, if answers such as the following need to be typed on the keyboard in response to a question on the screen—commutative, associative, distributive, identity elements, among others—it is very easy for students to experience failure. Rather, the answer to a question could have a multiple choice format such as

(a) commutative
(b) associative
(c) distributive
(d) identity elements.

Thus the student would only need to type in the letter a,b,c, or d on the keyboard in attempting to respond correctly to a programmed item.

Caissy[7] wrote:

Before an educator can begin to evaluate software, he or she must consider four general but important questions.

1. For what purpose will the software program be used? The answer to this question is likely to include one or more of the following objectives: to teach new information, skills, or concepts; to reinforce (through drill and practice) or supplement materials previously taught; to provide enrichment or remediation; to develop computer literacy; or to entertain.

2. Who will be using the program, in terms of grade level, age or ability level? If the software under consideration does not meet the developmental needs of the learner, it is unlikely to be used successfully.

3. What are the objectives of the program? Are these objectives clearly stated in the accompanying literature, and are they evident throughout the program? Does the program meet its stated objectives? (Many programs fall short in this respect because they lack a sound theoretical base, fail to rely on sound principles of pedagogy and instructional design, or are not organized logically and sequentially. In other cases, the learning tasks presented in the program are inappropriate to help learners meet the stated objectives.)

4. What knowledge or skills must a student posses in order to use the software program successfully? This is an important consideration. For example, must a student know a particular mathematical formula, understand a certain scientific theory, or be able to read music in order to use a given program successfully?

Correlating Mathematics with Other Curriculum Areas

The mathematics curriculum can be effectively correlated or related to other academic areas. Educational psychologists long have advocated that diverse academic disciplines be taught as being integrated to increase retention of learnings within each student. Academic disciplines taught as being in isolation tend to make it increasingly complex for students to recall subject matter. Why? If one idea, fact, or concept is received by any given

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[7] Gail A. Caissy, "Evaluating Educational Software: A Practitioner's guide," Phi Delta Kappan, December, 1984, page 250.

student, recall of related subject matter should be in evidence if content is perceived as being fused. With isolated content being the framework of a student, it is then difficult to trigger off related ideas. Aristotle (388-322B.C.) wrote an essay on this phenomena going back to the days of ancient Athens. Presently, most or all educational psychologists emphasize correlation, fusion, and integration of content from diverse academic disciplines.

How can mathematics be integrated with other curriculum areas. Computer-Assisted Instruction (CAI) can emphasize programs pertaining to the metric system. The metric system of measurement is utilized in most nations on the face of the earth. Thus, for example, in a social studies unit on Nation A and Nation B, computerized programs on the metric system can be emphasized, along with students studying the history, government, economic system, culture, and geography of that nation.

Graphics in software using microcomputers is very significant. Thus, circle, line, bar, and picture graphs could be programmed for student interaction pertaining to the previously named unit involving

1. average rainfall received for each month of the calendar year.

2. amount of each farm crop raised (rice, wheat, and barley) on the average per year.

3. kinds of livestock raised (cattle, pigs, and sheep) for each of the last ten years. Students may then see trends in livestock production, for each kind of animal raised, in making yearly comparisons.

4. types of exports from Nation A to Nation B covering the last five years. Comparisons are then made on a yearly basis in terms of increases, for example, of automobiles exported by Nation A to Nation B covering the preceding five years.

Students need to experience statistics at a young age level and experience continuous progress through the school years. Thus, first grade pupils (age six basically) can understand a picture graph based on personal experiences. For example, a picture graph could be developed for these young learners pertaining to which pupils have birthdays in each of the twelve months in a calendar year. Thus, if three pupils have birthdays in

January, three human figures on the screen would show the subject matter in a picture graph. Each of the other months also would be shown pertaining to the number of pupils having birthdays. With proper sequence in learning, students can ultimately become quality statisticians at their individual present levels of achievement.

Computer Managed Instruction (CMI)

Mathematics teachers over the years, no doubt, have utilized computer services to score tests. Also, test results have been stored on diskettes or cassettes for retrieval and future use. Much space is saved in keeping records by having test scores of students stored on either disk or cassette form as compared to more traditional forms of record keeping.

Printouts of test scores from students can be utilized by mathematics teachers to diagnose mistakes of individual learners. Thus, a teacher may notice errors such as the following with remedial procedures following:

1. computational errors in addition, subtraction, multiplication and division.

2. weaknesses in solving story or word problems.

3. structural ideas, such as students individually not understanding the property of closure.

4. vital concepts, such as place value, decimals, fractions, greatest common divisor, and least common multiple.

5. measurement of perimeter, area, and solid figures.

With Criterion Referenced Testing (CRT), mathematics teachers and parents receive printouts of the inherent measurably stated objectives and the related measurement procedures directly related to each precise objective. The mathematics teacher of course, guides each learner to attain the behaviorally stated objectives sequentially utilizing relevant purposeful learning activities. Also, the student can take the printout containing the ordered precise objectives home and secure parental assistance. Thus, parents may definitely be involved in helping their offspring achieve. There may be selected problems involved in having parents of secondary mathematics students help the latter achieve the precise objectives in the home setting. However, the mathematics teacher must provide adequate readiness experiences in the classroom setting so that the learner might attain selected precise objectives from the CRT. Parents must provide an appropriate study area and adequate supervision in order that the offspring may achieve as many sequential precise objectives as possible. Thus, a student can be guided to achieve in school as well as in the home setting in achieving precise objectives. New computer printouts need to be sent home of CRT's once a student has achieved objectives on the previous printout mailed home or taken home by the student to his/her parents.

CMI can also be utilized to give tests to students. Thus, diverse test items in multiple choice form are presented on the screen of the microcomputer. The involved learner types in the proper commands on the keyboard by typing a, b,c, or d as alternative responses. At the end of the program for testing, the number of correct responses are listed on the screen as percents. Any test item missed provides opportunities for remedial work so that mastery learning may be in evidence. A program may even prescribe new sequences based on specific items missed by the learner.

CMI assists mathematics teachers in many ways. These include

1. taking the drudgery out of checking papers of students in test taking situations.

2. keeping results of test scores of students from previous testing situations.

3. using CAI to assist in selecting objectives for a student based on items missed in a testing situation.

4. providing test results to teachers based on item analysis. The mathematics teacher may then provide remedial assistance to individual students based on incorrect responses of the latter.

5. producing hard copies of actual tests to be utilized. The printer attached to the microcomputer can be effectively and efficiently utilized for the development of tests to measure pupil achievement in attaining objectives in the mathematics curriculum.

Computer Literacy

Much has been written in professional educational journals and textbooks, as well as other printed materials pertaining to developing computer literacy within students. The writer suggests the following goals for student and teacher assistance in achieving computer literacy:

1. adequate self concepts need to be in evidence to confidently utilize microcomputers.

2. users need to be in control of the microcomputer being utilized and not be passive recipients of knowledge only.

3. teachers and students must realize that microcomputers execute commands given on the keyboard. If incorrect commands are given by the user, wrong results will accrue. Thus, microcomputers do what they are told to do.

4. there are things a microcomputer can/cannot do. Certainly, teachers and students need to know the capabilites and limitations of microcomputers.

5. adequate emphasis needs to be placed upon evaluating the quality of software utilized.

6. microcomputers may be utilized for a variety of purposes and philosophies. Among others, these include problems solving, drill and practice, tutorial, remedial, as well as to analyze, organize, and manage content and information.

7. inferential skills need developing pertaining to diverse kinds of graphs and graphic materials.

8. users need to master the use of the keyboard to type in commands accurately and efficiently.

To translate the above named into goals for learners to realize, relevant ends need choosing reflecting the utilization of microcomputers. For example, the following concepts might well provide direction for selecting objectives, learning activities, and evaluation procedures in using word processors.

1. control card--a magnetic card containing instructions for the central processing unit.

2. electronic typewriter--electronic in nature and not mechanical in operation. The number of moving parts is few and operates in a silent manner.

3. automatic carrier return--the operator does not need to return the carriage at the end of a line of type. Automatically, the carrier is returned by the machine. Automatic centering is completed with a keystroke command to the Central Processing Unit (CPU).

4. central dictation system--direct wiring of a system to a central location whereby dictation from others is received.

5. input--content which goes into a computer.

6. K (kilo)--represented by 1000 characters, approximately. Thus, 30K equals 30,000 characters.

7. keyboarding--the actual operation of a typewriter.

8. log sheet--a document which is used by supervisors to record cost efficiency as to incoming/outgoing work of computer service.

9. magnetic diskette--diskette which has a magnetic coat on which 130 pages, approximately, of typed content may be recorded.

10. magnetic tape--tape which has magnetic coat and is used for recording of information.

11. memory--within the Central Processing unit, an internal device in which subject matter can be stored and retrieved upon demand.

12. printer--a facet of the output device which prints content on paper.

13. record--storing typed content on a magnetic medium for use in the future.

14. search--a command to the word processor which causes the location of a specific section.

15. shared logic--two or more terminals can utilize the memory of the same Central Processing Unit (CPU).

16. software--includes manuals, programs, and flowcharts to assist in making optimal use of the computer. Software then are materials used to operate and control the hardware (computers).

INSERVICE EDUCATION AND THE COMPUTER

With an increasing number of computers in the curriculum, staff development becomes important. Societal trends emphasize a continual emphasis being placed upon the utilization of computers in the business world, as well as in personal lives of individuals. The school curriculum must not be separated from society. Thus, the computer has a highly significant role to play in teaching-learning situations.

Workshops as Inservice Education

A theme for a workshop should be selected cooperatively by teachers with administrative guidance. The theme must reflect curricular needs of a school. One relevant need in the curriculum might well be computer utilization in teaching and learning.

A first level of participation in a workshop should involve all participants in a general session. The leader and involved individuals should then identify problem areas or facets of computer use that should be studied. Criteria to be followed in the general session include:

1. All should participate and no one dominate.
2. Each participant should stay on the topic being discussed and not stray to unrelated areas.
3. Participants should respect ideas being presented. Minimizing or ridiculing ideas presented definitely hinders achievement in communication.
4. Ideas need to be presented clearly and meaningfully among general session members.
5. Content expressed by individuals needs to circulate among members in a group, rather than between the leader and a respondert in sequence.

Which problem areas involving computer use might be identified as relevant to pursue? The following are provided as suggestion:

1. Which criteria need to be followed in selecting computers which harmonize with objectives of the school and class?
2. Which standards need utilization in choosing computer software?
3. How might computers be utilized in problem solving activities in the curriculum?
4. How might programmed learning be utilized to provide for individual differences?
5. Which guidelines need following to assist learners to attain optimally in using computerized drill experiences.
6. How might simulations and games involving computer usage assist students to develop decision-making skills?

After an adequate number of vital problems have been selected within the general session framework, participants may choose which committee(s) to work in. Each participant should select committee membership based on the following criteria:

1. Meeting personal needs to improve the curriculum in the class setting.
2. Promoting perceived purpose by the participant in solving vital problems in the classroom setting.
3. Stimulating interest in wanting to use computers to provide for individual differences.

4. Developing an attitude of wishing to utilize computers effectively in ongoing lessons and ur.'s of study.

An adequate number of reference sources need to be available to assist workshop participan's to secure needed information in the solving of problems. These reference sources may include textbooks, periodical articles, pamphlets, films, slides, filmstrips, transparences, and illustrations. Proficient consultant and resource personnel also need to be available to participants in the solving of problematic situations.

In addition to general sessions and committee endeavors, individual participants also need opportunities to work on projects of their very own choosing. Thus, personal needs may be met in using computers in the classroom. A teacher, for example, may wish to develop his/her own programs for programmed instruction. Quality assistance needs to be available from an expert to guide teachers to develop their own programs of computerized instruction.

Achievements in committee work and individual projects may be shared with members of the total workshop within the framework of the general session. Whatever is acheived may, hopefully, be implemented in teaching-learning situations in the school/class setting.

In Closing

Software and microcomputer usage is becoming increasingly common in the school-class setting. Administrators, supervisors and teachers need to study philosophical implications involved in utilizing modern technology. What exists in society might well become salient to incorporate into the school curriculum. However, changes should not be made for the sake of innovation. There must be relevant purposes involved when incorporating microcomputer usage in the curriculum. Hopefully, students with teacher guidance may achieve at a higher level due to use of modern technology in the school and class setting

Sargent[8] wrote:

Computer-Assisted Instruction, CAI, is a good way to introduce students to the use of software that can perform prescribed tasks. Many teachers today find themselves faced with computer hardware but no appropriate software. Other teachers are faced with hardware and software that are too complicated to be really useful to most of their students. The authors of current software seem to know more about what the computer can do than about what needs to be done in the classroom.

If teachers can agree that CAI is valuable in the classroom, then teachers should encourage other teachers to develop software and to share it with their colleagues. We should publish in the public domain short, BASIC, classroom-tested, computer programs that are well integrated into current popular curricula. Short programs are easy to enter into the computer and to debug. They are easy for a classroom teacher with limited computer experience to tailor to particular classroom needs. Moreover, they are user friendly. If something goes wrong, it is easy to re-run the program from the beginning. Lastly, if a program is performing one simple function, it is easy for the computer operator—the student—to understand what the computer is doing.

[8]Bob Sargent, "Teachers Should Share Their Homemade Software, <u>The Clearing House</u>, October, 1984, page 57.

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