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ABSTRACT

This discussion first analyzes major claims of a cognitive-developmentalist perspective on the use of microcomputers in early childhood education. Five topics are specifically addressed: microcomputers and intellectual structures, microcomputers as cultural events, microcomputers and strategy repetoires, instruction and the self-construction of minds, and microcomputers as functional learning environments. In addition, the discussion offers an analysis of ideas concerning the interconnection between behaviorism and microcomputers in early childhood education. In this context, six topics are investigated: microcomputers and skill-training in education, major criticisms of the use of microcomputers in education, behaviorist theories and microcomputers in education, concerns about the skill-training use of microcomputers, behaviorist methodologies in Logo, and claims of behaviorism that go beyond behaviorism. It is concluded that, while the computer may have beneficial educational utility from a cognitive-developmental point of view, great care must be given to ensure that computers have a liberating rather than a constraining influence on children's cognitive development. Further, it is asserted that, while skill-training, microcomputers, and behaviorism will always play a role in early childhood education, the algorithmic nature of both microcomputer programs and behaviorism should not be allowed to predominate. (RH)

An Analysis of the Theoretical Foundations for the Use of Microcomputers in Early Childhood Education

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I. The Cognitive-Developmentalist Perspective

I would like to begin by responding to Barbara Bowen's paper which deals with the cognitive-developmentalist perspective on the use of microcomputers in early childhood education. I will do this by analyzing her major claims and then posing a number of queries.

1. Microcomputers and intellectual structures:

One of Piaget's major claims deals with how children build their own intellectual structures as they: 1) encounter and interact with physical objects, 2) interact with peers and adults, and finally, 3) manipulate various symbols. This is standard fare for the cognitive-developmentalist perspective. The question therefore arises whether interacting with blips on a CRT screen results in the same type of general schema as results from play with objects in the real world, and, whether microcomputers can provide adequate "materials to think with?" These questions are not easy to answer.

An initial attempt to answer these questions would no doubt point out that the schema which develop as a result of a child's interaction with physical objects are of a general, categorical nature. Hence, the concepts of object, causality, and conservation of number are really categories or structures of thought through which other things are conceptualized (i.e., the concept of "chairness" is intimately linked with the concepts of objectness and conservation of identity). Are objects on a CRT screen of such a nature that a child's interaction with them would develop categories of thought? To answer this, one need only remind oneself that "objects" on a CRT screen are defined by algorightms and procedures. It would have been just as easy to incorporate nonconservation of number (or identity) into the underlying algorithm (i.e., notice how easily identity, shape, size, and number changes in Logo sprites).

The next question that arises deals with whether we can even derive "ideas" from experience in general. For millenia, children and adults have played with falling objects but have never derived the concept of gravity from such object-interactions - a concept which adults consider important for children to learn in the modern world. This points out the importance of speech and cultural context for concept formation.

Finally, we must ask exactly what kind of symbols a computer can contain and whether the manipulation of these symbols is sufficient for the "self--construction of minds." Computers, as Weizenbaum points out in Computer

Power and Human Reason, manipulate empty symbols according to formal rules. They do not manipulate meanings. Hence, playing a microcomputer game to save the world operates on the same level as playing a computerized bingo game. Both are structured by quantitative algorithms and not by imaginative constructions. Computer languages, as such, are not really languages as much as sets of control-oriented notations. The construction of meaning (imaginative or otherwise) with a computer language or a computer application language is not the same as the construction of meaning through a personal/social language. More on this later.

2. Microcomputers as cultural events:

The next claim which Bowen elaborates from the cognitive-developmentalist perspective concerns the relation of children's cognitive structures to the materials which the surrounding culture provides. Conservation of number, so the argument goes, emerges in the minds of children because the culture provides many materials for this construct. The concept of self-reference and recursion do not emerge so readily because the culture is poor in "materials" for these constructs. I find myself both agreeing and disagreeing with this part of the claim. Finally, the claim is extended to state that computers are now cultural objects which fill in our culture's deficiencies in the latter two constructs.

This claim requires a careful analysis. I mentioned earlier that "objects" on a computer screen are based on humanly-constructed algorithms. They therefore reflect some human being's model of experience. What exactly will children experience when they interact with the resultant computer-based objects and processes (e.g., via microworlds and simulations)? This remains an unanswered empirical question.

We can, however, ask whether our culture has a deficit of procedures and processes for self-referential and recursive experiences? It seems to me that a major part of social-emotional growth deals with self-reference via individuation, decentration, and growth in personal autonomy within community. Furthermore, it seems that our whole experience of beliefs and value-structures deals with myriad examples of recursion (e.g., I believe that you believe that ...). R. D. Laing, in his book Knots, has spelled out many pathological forms of recursive beliefs. Our culture is therefore full of self-referential and recursive experiences. Whether our culture chooses to focus on, analyze, articulate, and conceptualize these experiences in the schooling process is another matter.

What about the claim that the computer-as-cultural-object will provide self-referential and recursive experiences for children? A computer is only a mirror of a small and limited part of our minds (i.e., the logical, quantitative, algorithmic part). Should this limited part of our minds become the basis for our self-referential experiences? Shouldn't we develop an understanding of self and recursion based on the richer part of our minds? This can easily be done by fostering social-emotional growth through self/other acceptance and understanding, and, by helping children apply analytical skills to the recursive nature of their own and other people's beliefs. Notice that in both of these examples, we are helping children confront the "buzzing, booming messiness", as Whitehead said, of both their world as well as of their own minds. This type of construction of meaning is based on real-life experiences. Learning about recursion in a computer program or other computer experience, on the other hand, is a pale construction of meaning by comparison.

One last point about computer-based experiences of recursion. Cognition, as Piaget said, reaches the formal stage at the end of a long process. Microcomputer experience of recursion, however, seems to impose the final formalism at the beginning of the learning process.

3. Microcomputers and strategy repetoires:

Another claim made by Barbara Bowen deals with how computers can "provide a vehicle for expanding the strategy repetoire ... [of] children for constructing physical knowledge." The example cited contains a simulation which shows the trajectory, simultaneous motion, and "freeze-frame" action of a log and a train. These features of a microcomputer simulation help develop hand-eye coordination, timing, and spatial skills. Video games provide a similar set of features in a highly-motivating situation. However, what exactly do these features contribute to the cognitive development of children? Again, we must await an empirical answer. We can ask, however, whether these features and the resulting "strategy repetoires" really form a basis for constructing physical knowledge.

First, the "strategy-repetoire" described in Bowen's example is most functional for immediate, non-reflective, action-based decision-making. Videogames force this characteristic. The simulation cited by Bowen at least allows some reflection during the freeze-frame action. However, whether the freeze-frame action allows the videogame skills (i.e., hand-eye, timing, and spatial skills) to be connected to higher-order cognitive strategies remains to be seen.

Second, the microcomputer simulation is the result of a programmer's judgement about the world that has been formalized into quantitative algorithms. Is this an adequate basis for developing a strategy repetoire to deal with the real world? Microcomputer simulations are always lauded for being able to provide experiences impossible in the real world. Are the experiences of 1+1=3 (or the transmutation of shape and identity or non-Newtonian gravity) an adequate basis for encountering and conceptualizing objects (let alone self and others) in the real world? We may have to wait until a generation of children grows up with video games to answer this question.

4. Instruction and the self-construction of minds:

Another claim by Bowen is based on Lawler's question: "how can we instruct while respecting a self-constructing aspect of mind?" This question is central for the cognitive-developmentalist theory of instruction because of the conflict of assumptions involved. Cognitive-developmentalist theories assume the self-construction of mind. Instructional theories, on the other hand, assume that a mind can be intentionally constructed by external agents. The microcomputer, according to Bowen, can be used in both ways. The example given reportedly respects the self-constructing nature of mind but it does raise some questions.

No one can deny that the Lawler's BEACH microworld empowers the young to use alphanumeric notation to "make things happen and create interesting phenomena." What exactly does empowerment mean here, however? To answer this, we must come back to the nature of computer languages. "Words" in a computer "language" are actually alphanumeric symbols that function as a notation system to control computer operations. They are based on a control metaphor and can be thought of as explicit tools for thought as long as their control orientation is kept in mind. They are not tools for thinking, meaning, and expressing as with natural-language words. Empowerment within a computing environment (either with a computer "language" or with an application "lang..ge" of a simulation) is control oriented and not meaning-construction oriented. Experience with computer "languages" therefore leads to a different kind of mentality than experiences with natural languages. The self-constructing nature of mind is severely limited with computer experiences. This is not to suggest that computer-based learning experiences should be avoided but that they should be carefully bracketed within other experiences.

5. Microcomputers as functional learning environments:

Finally, we come to Bowen's claim that the Talking Screen Textwriting Program (TSTP) provides children with a "functional learning environment

... [of] multiple modalities." What exactly does this mean from a cognitive-developmentalist perspective? In the TSTP microworld, a child types a letter (or word) and hears the sound of the letter (or word). This seems as much a "sub-skill" in a child's literacy development as spelling, grammer, and so on. But what is the cost?

I only have a series of questions about the TSTP experience at this point. Where is the human intentionality of a speaking/responding agent in TSTP? Where is expressive inflection from which we infer so much meaning in speech? Where is the dialectical nature of human speech-interaction through which we learn to create the context for reading and writing? Where is the child learning to construct speech based on internal prototypic meanings? Where is the reflexive nature of language that helps a child develop greater precision in expressed and communicated meaning? You can see from my questions that I consider the TSTP simulation a form of mechanical triggering of algorithmically-predefined artificial speech. This may be good for encoding and decoding of sounds but certainly not for the development of language and thinking.

Summary

Barbara Bowen finishes her paper by claiming that:

> the computer [can be] used to empower or extend the child's relationship to knowledge valued by the adult world, socially important knowledge, and also to provide the child with a functional learning envirenment.

I agree with this summary statement both personally and from a cognitive-developmentalist v..wpoint. But I also believe that each part of this summary statement must be heavily qualified in order for computers to be liberating rather than constraining influences on the cognitive development of children.

II. The Behaviorist Perspective:

I would now like to respond to Dr. Golub's paper. Dr. Golub presents a very provocative set of ideas about the interconnection between behaviorism and microcomputers in early childhood education. I will analyze and summarize some of his claims.

1. Microcomputers and skill-training in education:

Dr. Golub begins with an observation: computers will always be used in early childhood education because our schools will always deal with skill-training in one form or another and because microcomputers are useful for such training. The behavioral perspective, he therefore concludes, will always play a central role in education. Leaving aside the question of whether skill-training should predominate in early childhood education, Dr. Golub's conclusion seems to be borne out by a number of recent national studies on the current state of education.

2. Major criticisms of the use of microcomputers in education:

Dr. Golub goes on to summarize some of the more popular arguments against the use of microcomputers in early childhood education: micros are nothing but expensive page turners, children who learn from micros are reduced to mere button pushers, and computer-assisted-instruction (CAI) is no better than traditional teaching. Many of these criticisms were echoed by Dr. Bell in a recent speech.

Dr. Golub then counters each argument: microcomputer courseware deals with a new penomenon called "frames" and not pages, what a child does at a keyboard is a matter of instructional design and can therefore be changed, and, research in the 1960's and 1970's clearly demonstrated the effectiveness of CAI with specific content when compared to traditional teaching. These are standard responses. Dr. Golub's counter-arguments indicate a deeper concern, however. Criticism of microcomputers in education may actually be focused more on technological features than on the validity of behavioral theories. Let me explain.

Books as we now know them are the result of several hundred years of experimentation and evolution. Hence, features such as indices, page numbers, titles, footnotes, and gramatical and linguistic conventions were developed to work with book-based technology. A comparable evolution is now taking place for computer-based technology. Courseware authors may very well be borrowing ideas from book-based technology but they are rapidly evolving structures and approaches appropriate for computer-based technology. Hence, the notion of "frames" in computer courseware encompases both static textual and visual information as well as interactions with that information. Much criticism of microcomputer courseware therefore deals with features that will soon be superseded.

There is a sense in which the stereotypical criticisms of CAI courseware have some validity, however. When books are used in the learning process, human teachers provide a model for the interactions with the information. In a CAI program, on the other hand, a programmer/designer preplans much of the interactions. Adding individualized "bells and whistles" such as levels of difficulty and rates of progress does <u>not</u> alter this basic fact. Even expanding the user's choice, as in simulations, does not alter this fact. We therefore need to ask ourselves about the types of learning where such pre-planned interactions are appropriate and where they are inappropriate. It is here that behavioral theories of learning become useful. More on this later.

There is another sense in which the stereotypical criticisms of CAI are valid. Since much of the <u>current</u> microcomputer courseware does in fact repeat many of the mistakes made by early CAI systems, teachers have to supplement and complement such programs in the classroom. This defeats the purpose of predesigned interactions since that purpose is to increase the work potential of teachers (usually defined in terms of an increase in student performance per teacher effort expended).

Finally, there may be some validity to the charge that CAI is not better than traditional teaching. What exactly is being compared, however? Research has demonstrated the effectiveness of CAI when compared to traditional teaching but only when we focus on the narrow domain of prespecifiable and observable performance gains. Traditional teaching, on the other hand, encompases a much wider range of activities and "outcomes." We should therefore evaluate CAI and traditional teaching on their own terms. Behavioral theories can play a useful role here also. This brings us to the heart of Dr. Golub's paper.

3. Behaviorist theories and microcomputers in education:

Behaviorist theories of learning, as Dr. Golub suggests, encourage us to:

a. learn one small, measurable skill at a time,

b. reward the learner when a sub-skill is learned,

and, c. order skills in an easy to difficult hierarchy.

Such theories therefore tend to work best for skill-hierarchies. That is:

a. they are biased towards gradual, accretion learning because the content is broken into a hierarchy of constantly-measured performances (and therefore biased against discovery by, quantum-leap learning),

b. they deal with pre-specifiable and measurable end points (and not with intersubjectively constructed and discovered goals),

c. they are bound to objective data (rather than to interpretation and human judgement),

d. they treat learning as an algorithm-constrained (some would say algorithm-driven) process (notwithstanding the individualized bells and whistles mentioned above),and,

e. they separate the conception of teaching from the execution of teaching (the former usually being done by professionals who are guided by research consernsand theories of learning rather than by classroom encounters).

Each of the features of behaviorist theories described above work well within a computing environment. The reason is simple! As I mentioned in response to Barbara Bowen's paper, computers manipulate empty symbols according to prespecified algorithmic rules. Furthermore, they need constant data from the environment in order to control some process in the environment. Prespecified behaviors constitute a kind of measurable set of empty symbols from which we infer internal meanings. Once specified, we can proceed on the assumption that they indicate such meanings and intentions. Computers therefore work well in education within the very conditions spelled out by behaviorist theories of learning. This is not to suggest that computers cannot work within other conditions. However, the whole point of introducing capital-intensive solutions into education is to free up the teacher to be more productive (i.e., more "creative" as the euphemism goes). Microcomputers will therefore tend to be used in the stand-alone, skill-training mode because other modes require more teacher knowledge and engagement.

4. Some concerns about the skill-training use of microcomputers:

The skill-training mode of microcomputer-based learning is not without its problems. First, there is the problem of students who misinterpret microcomputer instructions. Dr. Golub readily admits that even though CAI can only be used with clearly-delineated subject matter, students might still interpret things differently from the courseware authors. Hence, teachers will have to be present "to receive the child's expressed thoughts [when they] differ from the expectations of the author." Doesn't this add more work for teachers and undermine the whole point of this type of microcomputer-based education? Doesn't this also go beyond the behavioral paradigm (i.e., intentional dialogue, human agency, and interpreted meaning)?

Second, can CAI really teach concepts as well as teach skills? Dr. Golub seems to think so but this remains an open empirical question.

Finally, do we want our children to model themselves after the algorithmic formalisms built into computer courseware? This may be very useful when children "play turtle" in order to learn simple geometric concepts. But what about the times when they incorporate the preprogrammed interactions into their mental structures? Dr. Golub gives several examples of this that warrent further analysis: a "prompter system" that helps children generate poems and a "prompter system" that helps children "generate sentences according to linguistic structure patterns." My concern with these microcomputer programs is that they automate the process and not just the tools of poem generation and sentence construction. Children therefore incorporate a predefined structure of thought rather than learning how to create structure and meaning simultaneously under the real-time guidance of a human being.

5. Behavioristic methodologies in Logo:

Seymour Papert has given much impetus to the use of microcomputers in early childhood education. The Logo turtle and Logo turtle graphics are seen as "transition objects" for children as they pass from the concrete-operational to the formal-operational levels of cognitive development. How behavioristic is Papert's theory and are there an drawbacks to using Logo as an "object to think with?"

Dr. Golub makes several claims about the behavioristic dimension of Logo. On further examination, however, Logo may not fit into the behavioristic perspective as well as CAI fits into the skill-training mode of learning.

First, Logo encourages children to act out computer commands by "playing turtle" with their bodies. True, acting out is a kinu of behavior but it is motivated by the inner intentions of play and exploration rather than by a desire to shape behavior (or by the desire of someone else to shape the child's behavior). Playing turtle therefore does <u>not</u> seem to fit into the behavioristic perspective.

Second, Logo encourages children to "debug" their programs and not worry about right and wrong answers. Wrong answers, in fact, become occasions for learning and discovery in new and unexpected directions. Debugging, as an educational strategy, therefore also does <u>not</u> seem to fit into the behavioristic perspective.

Finally, teachers must ask themselves a number of questions for Logo to be an effective learning tool. Dr. Golub summarizes these questions very nicely: 1) what is discoverable, 2) what is best taught, 3) how and when should a teacher intervene, and, 4) how should a teacher structure the classroom for peer interactions? Notice, however, that each of these questions (and the resultant teacher actions) go beyond the behaviorist perspective. Instructional outcomes are not preplanned and instructional strategies are not algorithmically-driven. Rather, the teacher engages the actual uniqueness of the classroom situation and develops goal structures as he or she goes along.

What about the drawbacks of Logo: Dr. Golub does not address this question but I would like to add a number of comments. First, do we really want our children to act out computer commands with their bodies? How will this lead to a concept of body as an agent of expression and intensional movement? Do we really want to see our children begin to see themselves as "walking variables" that "carry" certain values? You can see my bias from my questions.

Second, is debugging a computer procedure really an adequate preparation for solving problems in real-life situations? Logo "bugs" are only bugs with respect to Logo syntax and require syntactical resolution (there are no right or wrong answers on the semantic level in Logo, remember). Real-life situations, on the other hand, require information gathering, question asking, critical thinking, and semantic "debugging." Furthermore, real-life problems are often paradoxical and contradictory in nature and are only "solved" by coming to terms with their unresolvable nature. Wouldn't it be better to challenge children with simple real-life problems that get progressively more complex as children grow older? Contrast this with Logo's artificial, algorithmically-constrained, syntactical problems! Here again, you can see my bias.

Finally, shouldn't we make the questions that teachers ask themselves part of our children's concerns? Hence, questions such as what is best discovered, what is best taught, and is the environment best structured for peer interaction seem to be questions that any person who wants to learn how to learn must confront. These factors all go beyond behaviorism. They also go beyond Logo.

6. <u>Beyond behaviorism and microcomputers:</u>

Dr. Golub makes several further claims at the end of his paper that go beyond behaviorism. For example, he claims that CAI learning experiences are not harmful to children if we let children make intuitive and cognitive statements about their experiences. Is he suggesting that the behavioristic mode of learning is harmful to children when expressive outlets are not provided? What role could CAI have under these conditions?

Second, Dr. Golub claims that we should allow children who are not ready or inclined to work with computers to turn away from computers and work on other activities. This is an admirable admission. But, what happens in a classroom where learning has been reformulated into a behavioristic hierarchy so that a child is not allowed to "mess around" with higher-order skills until thay have demonstrated competency with the lower-order skills? Again, Dr. Golub seems to be suggesting that not only the teacher <u>but also the student</u> should be allowed to overrule the behavioristic mode of learning.

Finally, Dr. Golub suggests that some children are people-oriented rather than object-oriented. Such children will never feel comfortable interacting with a microcomputer in a learning situation. What do we do with people-oriented children if we use CAI as a major tool in schooling? My own answer is that we should be focused on "people-making" in the first place when we use microcomputers in early childhood education.

7. Summary:

Dr. Golub's paper has touched on many important issues in the behavioristic perspective. Skill-training, microcomputers, and behaviorism will always play a role in early childhood education. We should be very careful, however, not to let the algorithmic nature of both microcomputer programs and behaviorism get an upper hand in such education. Use microcomputers to automate the tools but not the processes of education. And above all else, subordinate skill-training under "people-making" in eraly childhood education.