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ABSTRACT

While there is a genuine hope among some educators that computer use will radically restructure the process of education, and fear from others that it may very well succeed in doing so, it is unlikely that such aspirations or fears should be held for early childhood education at this time. Nor does it seem likely that the situation will change quickly. Evidence from both theoretical and empirical sources suggests that computers by themselves are not advantageous or disadvantageous for young children. As with any new item of preschool equipment, their value depends on the context within which the item is used, and on the manner in which the environment for learning and development is established by teachers and parents. A number of observational studies need to be done before it becomes evident which variables should be investigated. Adults' perceptions of computers, and their expectations for their use, will shape the way in which they will be used. The theme of this paper is that careful thought must be given to the model of education being promulgated when computers are advocated for young children. (RH)

Computers and the development of young children.

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The study of child development is concerned with a variety of topics, and makes use of several theoretical and research approaches. While neither the topics nor the approaches are free from implicit assumptions and explicit conceptual frameworks, discussions of the theoretical bases are infrequent. Yet if we accept that theory "serves as an integrator of existing facts and as a basis for the derivation of new facts" (Lerner, 1976, p.5) any significant change in settings intended to influence children's development is expected to attract empirical and theoretical investigation. The present paper argues that pressure for young children to use computers in early childhood education comprises such a significant change; and that while several empirical investigations have been reported, most are not related to a theoretical framework from which "new facts" may be derived; and further, that the disciplines which underpin the study of early education have failed to examine or produce appropriate ecological and developmental perspectives.

In order to undertake such an examination, we need to consider: the pressure for young children to have "computer experience"; the arguments advanced in favour of the use of computers with young children; the evidence about young children's use of, and the consequences of their using computers; and the relevant theoretical issues.

The pressure for early computer experience

It is widely accepted that the introduction of computers into primary (elementary) schooling is one of the most important developments in education over recent years. Bork, for example, claims that "The computer is the most powerful new learning device since the invention of the printing press" (1984, p.178). This claim is apparently supported by leading administrators: the Assistant Secretary for Educational Research and Improvement in USA, has recently noted that "computers in the classroom" was fourth equal in a listing of areas of educational enquiry likely to produce a significant impact on educational practice during the next five years (Finn, 1988). There have been few rigorous evaluations of these claims. Most of the computers currently in schools have been purchased from funds raised by parents, which reinforces the perceived desirability of the technology.

Computers are also now regarded as everyday items of equipment in early childhood centres in USA. For example, 25% of licensed preschools in 1986 possessed at least one computer; all were expected to have one or more by 1989 (Goodwin, Goodwin, Nansel & Helm, 1986). There are several Australian studies of computers and preschool education (for example Blemings, 1985), and considerable interest being shown in New Zealand. But there is no body of literature advocating computer usage in preschool comparable to that available for teachers and educators concerned with elementary or secondary schooling. The main justification for introducing computer experience early thus appears to be a simple case of "me too": if they are good for school-aged children, the younger siblings must also be given a turn.

Many families own a personal computer, and many more use or have access to one. There is subtle pressure to consider purchase: marketing something as "educational" encourages parents to believe they will gain an advantage for their children; and the emphasis on learning while working with a computer makes it readily marketable. In USA, for example, Hill has commented on television commercials which claim that "unless preschool children have the

opportunity to work with microcomputers they will be unsuccessful in college" (1984, p.1). But even if parents do not buy a computer for their own use, they may expect the preschool to provide one or more. There are signs of this pressure in New Zealand. A recent article in the Playcentre Journal (for parents in a cooperative preschool service), reports a study in which one result was that:

> Many parents were in favour of having a computer in both kindergarten and in the home. They reasoned that as computers are now part of the work place, children and young adults are going to have to come to terms with the new technology - so the sooner the better. (Podmore, Slowley, Agnew & Renwick, 1988, p.36).

Whether the parents' beliefs as represented by such statements reflect a view of education that early childhood centres want to foster is debatable: the Playcentre movement in particular has often argued in the past that it does not provide preschool experience as specific preparation for schooling (see McMillan, 1977, for example) let alone preparation for work experience ! But the quotation above suggests that the advertising has either worked, or is capitalising on the assumption that further education and employment will benefit from preschool experience of computers. The pressure parents and preschool teachers are reacting to thus reflects a belief that computers have significant and inevitably positive outcomes. To Kreuger, Karger & Barwick (1988), this belief can be construed as part of the capitalist consumption ethos, in which exposure to computers

> represents a way to cut down on unproductive and wasteful play time, substituting instead an early familiarity with the world of technology ... (which) increases (children's) human capital and thereby gives them an edge in the workplace of the future. ... While at one time we sacrificed young children to a desperate labor, we may now be sacrificing another generation of children to the process of preparing for labor. (p.78)

A belief in the importance of early computer experience may thus reflect no more than the successful manipulation of public opinion, rather than evidence as to its value. Provision of evidence is unlikely, by itself, to prevent the manipulation, but what is available needs to be examined. We shall first review the arguments in favour of early computer use for children.

The arguments advanced in favour of the use of computers with young children

One could infer from the preceding discussion that the "computer experience" some parents want for their children was not focussed on specific learning, but on a generalised awareness of "a computer", and how it worked; and on a hope that experience with a computer would ensure future employment. Such an argument has been designated as advocating "computer literacy". Programmes designed to achieve "literacy" are currently not in favour among educators who realize that neither children nor adult users need to know about "hidden" computers (in places such as banking or check-out machines) in order to use them effectively. Given the rate of technological development, an argument for computer experience based on the premise that "earlier is better" is even less valid in the context of early childhood education: when today's workforce entrants were in preschools, personal computers were hardly known.

A second argument for computers in education emphasizes their role in learning specific material. Programmes providing drill and practice for basic mathematical concepts, relationships, word recognition, and so on, are common. This approach to learning has also been criticised, for the construction of knowledge involves much more than recitation of memorized information. But a growing number of programmes available for young children continues to rely on rote-learning. Burg (1984) advocates using computers in kindergarten (5-year-old children) in terms of games for number work, language (letter- and word-recognition), colouring and drawing, and other "developmentally appropriate experiences" (although these are not further defined). There are occasions when instructional software can be useful. But in early childhood education, the curriculum emphasizes children's development and learning, not instructional activities. The fact that children can learn from such activities does not mean that they should be prescribed experiences.

Current thinking about computers in education generally, emphasizes their part in the total learning environment (Pea and Sheingold, 1987). A variety of expressions of this idea can be found in the literature of early childhood. Beaty and Tucker (1987) argue that a computer does not replace any of the traditional activities of a preschool, but "can enhance the use of games, books, and other preschool activities" (p.30). However, these authors also advocate that a typewriter, for example, should be part of early experience, "not to teach the children to become typists, but to give them an opportunity to explore and learn the properties of a new implement ... to hone their small motor skills ... (and) learn to recognize letters". (p.38)

The argument seems again to imply that the justification for including an item of equipment (computer) is in terms of its future benefits, rather than its current educational value. We do not advocate providing all possible "implements" for preschool children to explore: would gambling machines teach number ? Why advocate using one machine, on the untested assumption that whatever is learned will generalise to another ? Yet Beaty and Tucker claim that "Because the computer has a typewriter keyboard, using a typewriter first is a fine introduction to the computer" (p.38). In fact other writers recommend avoiding the keyboard altogether: even though they can be mastered by children, other input devices (pressure pads, joysticks, touch-sensitive screens) are preferred (Tan, 1985).

But whether the input device is a traditional keyboard or a simpler system, there is a larger issue: the programmes for young children, and the "educational experience" assumed to be gained by the children is using it. The "standard equipment" of a preschool depends on direct sensory contact and manipulation of real objects, even though imaginative uses are encouraged. But a computer screen provides only two-dimensional experience, limiting the opportunities for comparable direct experience. As Cuffaro observes,

> what has been selected from the existing early childhood curriculum are those activities that are adaptable to the functioning of the microcomputer ... technology has determined the predominance of skill-oriented activities". (1984, p.564)

Perhaps an example will illustrate the point. A series of programmes ("Sticky Bear" software) is commonly recommended for children from three to six years of age. These programmes "teach" children to differentiate shapes, recognise numbers, or identify relationships ("up" and "down") for example. Of course, parents and children can interact in this way without a computer,

but when one is available, it is one means of engaging in enjoyable exchanges (McMillan and Thomas, 1987). This kind of software can be used valuable when children have particular needs: those with a physical disability, for example, can find the visual stimulus and simple control mechanisms of a computer of real value. But whatever the abilities of the children with whom it is being used, and whatever the incidental outcomes of using it, the programme's educational merit is limited to the acquisition of specific knowledge.

The educational value of computers is more apparent when children are older, and capable of independent reading, writing, and responding to as well as creating programmes. For example, Logo (see Papert, 1980) is a computer language specifically written so that children can use "ordinary language" (such as "forward", "left turn", and "back") to move a "turtle" on the screen, by giving it an input (distance forward, or angle to turn . These instructions can be built into procedures, which may individually be simple, but together, extremely complex. Since every instruction entered by children results in immediate feedback (the turtle moves as instructed), they have a direct learning experience, and can come to learn some very powerful ideas. There is a substantial body of literature regarding the use of Logo with older children (for example, Papert, 1987; Pea & Sheingold, 1987; Weir, 1987). Young children have also been taught to use a simple version of Logo (see Vaidya, 1985; Lawler, 1985), but it is not at all clear that there is any necessary benefit from having children under six years of age do so.

In terms of this brief analysis, the argument in favour of the use of computers with preschool children is not strong. It could be that the arguments will become more clearly articulated as evidence become available, and for that reason, the current evidence needs to be considered.

The evidence about the processes and consequences of computer learning

While there is often enthusiasm for computers in education, the evidence in favour of doing so is limited. One recent report comments that "the existing evidence of computer effectiveness is very scanty if we prudently refuse to collapse such disparate studies as a system-wide effort to raise Chapter 1 students' math and reading scores, a writing project of a single junior high English teacher, and an evaluation of computer programming's effects" (Becker, 1987, p.23). We certainly can not assume that there will be benefits from computer applications in early childhood education. Unfortunately,

> Much of the current thought in this area is based on the personal experiences of interested professionals, observation, limited demonstrations of various techniques and descriptive studies involving limited numbers of students. (Waldrop, 1988, p.59)

Only studies providing data concerning the early childhood years (including kindergarten and first-grade children) are reviewed here. Burns and Ferguson (1988) study of five- and eight-year-old's knowledge about computers, attempted to measure "aptitude" for computer work. No data on aptitude are yet published, but the report shows that almost all of the children had previous experience of computing in their homes, and had a reasonably sound knowledge about the machines. "Games" were the most common activity reported for the third-grade children (nine of the thirteen children), but "drawing" was more common for kindergarten-aged children (nine of fourteen).

In a descriptive study of a group of 39 children (from four to seven years) Silvern, Williamson & Countermine (1988) report the outcome of providing free access to a computer during a Summer School programme. Only one-third used the computer, with five- and seven-year-old boys predominating. The most frequent use was "manipulative" games (using a game-paddle to move the screen object, as opposed to "cognitive", or thinking strategy activities).

A number of studies have looked at the social consequences of computer use. Lipinski, Nida, Shade & Watson (1986) looked at what happened to free play activity when a computer was introduced into each of two separate preschool classrooms. Baseline data were obtained for a week, and a second week provided "non-interactive computer presence" to allow for the class's adjusting to the computer. Two further weeks of teacher-interactive computer experience followed. In both classes, the presence of a computer initially disrupted free play, but children quickly (within the two final weeks) returned to previous play patterns. The authors report that the computer did not lead to social isolation of children, nor changed the positive social interactions among children. One class showed a sex difference favouring boys, but the other revealed a trend in favour of the girls. A New Zealand study partly replicating the Lipinski et al strategy (Podmore, Craig & Atmore, 1987) confirms the positive influence computer activity had on preschoolers' socialization, and notes an increase in "talking to peers about the activity".

Conventional wisdom suggests that children are likely to enjoy working with computers. Preschool children in a University laboratory have been shown to be positive about computer activity (McBride & Austin, 1986). But Goodwin, Goodwin, Nansel & Helm (1986) demonstrated that three- to five-year-old children showed a lower level of interest in computer activities (of the "Sticky Bear" instructional kind) than did a control group; and further, that the control group's level of interest declined after having received similar computer time. Given that they had only three 20-minute sessions at the computer, the children's reported level of enjoyment could be influenced by the software, the context within which the computer was located (including the teachers' opinions about it), or the assessment measures themselves.

Younger children's "enjoyment" of activities also reflects more fundamental factors. While the data from their observations of 79 children aged 4:2 years to 5:11 years are not given, Haugland and Shade (1988) used ten criteria (such as age appropriateness, clear instructions, independent exploration) to evaluate the developmental appropriateness of software for young children. In reporting the ratings assigned to the software, the authors note that most software does not reflect a developmental approach to teaching and learning.

While the previous study assigns "external" criteria to the task of deciding if software is appropriate, there are other factors. For example to Papert (1980), Logo is partly a language for programming a computer, but it also embodies a philosophy of education. He takes as the model for children's learning, the way in which "natural language" is developed:

> If ... the model of successful learning is the way a child learns to talk, a process that takes place without deliberate and organized teaching, the goal set is very different. I see the classroom as an artificial and inefficient learning environment that society has been forced to invent because its informal environments fail in certain essential learning domains, such as writing ... or school math. (p.8)

His emphasis is specifically on "Piagetian learning", by which he means "supporting children as they build their own intellectual structures" (p.32). Logo found willing acceptance among many educators who see its links with Deweyan progressivism and a liberal independence. Logo also has detractors (Pea & Kurland, 1984), although Emihovich and Miller suggest that it is inappropriate to evaluate Logo as a programming language, or as a method of instruction: instead, it creates a context for learning (1988, p.57).

Some contextual effects were demonstrated by Clements and Nastasi (1988), in a study of 24 grade 1 children (mean age 6:6 years) and 24 grade 3 (mean age 8:8 years) in two groups, for Logo or CAI drill-and-practice treatments. A major result was that while both groups spent equivalent amounts of time working cooperatively, the Logo group demonstrated a significantly higher amount of conflict resolution as a consequence of their continual negotiation about problem definitions and solution strategies; also more self-directed work, and more metacognitive behaviours. While the data require replication and longer period of follow-up, they tend to confirm some aspects of Papert's theory.

A different aspect of the computer culture envisaged by Papert has been reported by Lawler (1985), in which he details his young daughter's exploration of Logo. It is a rich data set, showing the powerful use to which the language can be put when it is in the context of a family who know the system, and can raise significant challenges for the child to experience.

A study by Williamson and Silvern (1986) is an example of Logo being examined carefully, but in a manner Logo enthusiasts find inappropriate. Twentytwo parent-child pairs (in which the children were aged from four to nine years; average 81 months) were enrolled in a ten-hour Logo programme. Parents were informed that the class was primarily for the benefit of the children, and that they should be patient and help them. Despite that, the study found that the parents were "overwhelmingly directive". Yet it is questionable whether the instructional environment was a supportive Logo culture, as Papert intended, when standard Logo appears to have been used with even the youngest children, rather than a "microworld" of limited options to encourage exploration, and avoid the necessity for parents to master many commands.

All of the preceding studies suffer from being of limited duration, and of course it is difficult to make conclusions about developmental issues when longitudinal work is neglected. Fein, Campbell and Schwartz (1987) address that problem, with a study of computer use among thirty children in a laboratory preschool. Two computers were provided, with two chairs for each to encourage paired play activity, and observations carried out over a three-month period. At first, the computers had little uniform effect; but by two months, it was clear that less unoccupied behaviour, less interactive play, more parallel play, and less dramatic play, occurred when the computers were in the classroom. The effects were thus varied, and the authors note that

> while the microcomputers did not promote solitary functional and solitary dramatic play, behaviors associated with adverse developmental outcomes, they also failed to encourage parallel constructive or interactive dramatic play, behaviors associated with positive outcomes. (p.205)

These studies suggest that young children can engage in computer activities, but do not always enjoy activities using commercially available software; that there are no apparent ill-effects in terms of socialization; and that Logo could be a particularly appropriate developmentally for children.

Theoretical considerations

The preceding discussion suggests that young children can use computers, but that the consequences are not as predictable nor as positive as some would wish. Waldrop (1988) however considers that the question "Can they use them ?" must be followed by the quest for a justification: "should computers be used to teach young children ?" (p.61). Yet even phrasing the issue in that manner assumes that teaching (in the sense of instruction) is the purpose of early childhood education, and that the main purpose for having computers is to engage in teaching. Such issues need to be examined.

In most Western societies, early childhood education is provided by a variety of organizations separate from those administering universal and compulsory schooling. There is consequently a de facto distinction between the goals applying to each, but discussion of early childhood goals has tended to be overshadowed by the more pressing concerns of the extent of provisions for and funding of early education. A study of provisions in Scotland, for example, is devoted primarily to the extent of the service available, while the discussion of the goals as perceived by parents is phrased in very brief and general terms such as "the child would benefit from the experience" (Haystead, Howarth & Stachan, 1980, p.64). Nevertheless there are clear statements of the purposes for early childhood. Spodek (1982) has commented that preschools in USA reflect their Froebelian, child-centred orientation, strongly influenced in later years by child development studies. A number of writers (such as Tizard, 1974) refer to the "holistic" understanding of children's development represented in the field, by which is meant that traditional early childhood "has always stressed that cognitive goals cannot be clearly separated from non-cognitive ones" (p.86).

The field of early childhood education is, however, strongly influenced by more recent disciplines also. Applied developmental psychology has much to do with children, and the family and social settings in which they develop. In fact, for the last twentyfive years, early childhood education has been dominated by developmental psychology (especially in studies of remedial intervention, parenting and parent education, and the developmental outcomes of various practices). While the arguments among developmental psychologists about early childhood education are not as vigorous as they once were, there is still a considerable body of literature relating to the topic. Yet theoretical considerations of elementary and secondary education have reflected a major input from disciplines other than developmental psychology. The field has not been absent, as studies of language, mathematics, and "moral issues" or "human development and relationships" for example, show. But a "developmental perspective", by which is meant a concern for both idiographic and nomothetic patterns of change over time and the interactions between changes and the contexts within which such changes occur, is not prominent in discussions of educational practice at these levels. The major focus in psychological discussions of schooling has to do with learning, its processes and outcomes; and inevitably with the teaching associated with the learning.

The study of computer applications in education often reinforces the notion of learning as being significant: not surprising perhaps, for "computer assisted learning" itself derives from a Skinnerian approach to human behaviour. One would not expect, however, that a paper entitled "Psychology and educational computing" (Hannon & Wooler, 1985) would totally ignore developmental or even age-appropriate references: the assumption is that computing and schooling at

all levels have the same concerns. Collis (1988) does acknowledge age differentiation as an issue but nevertheless lists only one lesson plan from a total of 98 as being appropriate for the kindergarten grade (five-year-olds).

Computer applications in education do not represent a single philosophy of education. But the advertising of software emphasizes learning as the major factor shaping young children's behaviour. The problem is that such thinking is predominantly interested in specific behaviours: counting sequentially, recognition of objects or words, and so on. It implies that learning these items ensures adequate educational experience; that they should be learned at a certain age; and that instruction from a teacher (or computer) is necessary if they are to be learned. Kohlberg describes this as the "psychologist's fallacy": statements about what ought to be valued are derived from psychological statements describing what is (Kohlberg, 1987). Teachers of young children know that "what is" reflects a complex interaction between developmental processes, family and social contexts, and uniquely individual responses to experience. To assert that a certain item of software ought to be part of each young child's learning experience, or (even worse) to assert that experiencing that software will produce predictable outcomes, flies in the face of the variability we meet in early childhood centres.

Kohlberg suggests a classification of theoretical positions for early childhood education. He notes that we commonly find in traditional programmes, the "bag of virtues" strategy, reflecting the romantic heritage of writers such as Rousseau. In this, goals are expressed in appealing but simplistic terms (helping self-confidence, spontaneity, curiosity, for example). While few would disagree with these as desirable traits, it is difficult to define them unequivocally, and consequently they are claimed to be "not stable" or "have varying interpretations in different c tures". Thus they are not useful justifications for educational practice, for they are not amenable to clear definition, or agreed measurement.

A strategy which does have clear and measurable goals is termed by Kohlberg the "industrial psychology rationale", based on the empiricist tradition of Locke. The problem when this approach is used in early education is that the measurement practised here depends on relative status: that is, assessments of children's progress are norm-referenced. "Success" is defined in terms of achieving at a higher level than one's peers. In order to achieve this success, one must learn the specific tasks which are to be used in tests (of selection or attainment). And it is probably better to learn these tasks earlier (in order to obtain a "headstart"). The result is reflected in the quotation from a New Zealand study of early childhood at the beginning of this paper: if you want a job in later life, learn about computers in preschool.

The strategy Kohlberg advocates is designated the "cognitive-philosophic" strategy. It reflects a cognitive-developmental perspective on human development, deriving from Piaget's views of qualitative changes in the way ideas and objects are perceived and represented in human functioning, and which provide the basis for the organisation of action. Decisions about what learning is "appropriate" are based on a broad view of an individual's developmental characteristics, rather than a narrowly-defined set of "norms".

The educational model which corresponds to this cognitive-philosophic strategy has come to be termed the "constructivist" view. The term signifies that its roots are in a Piagetian perspective on development, in which the meanings actively constructed by the individual (the ways in which we "make sense" of

our experience) are crucial to all learning. The primary propositions in this framework are· that play and learning experiences need to encourage the active involvement of children in developmentally appropriate ways (with an emphasis on sensory-motor, and concrete experiences in early childhood); that individual children will construct independent meanings as a result of their activity; and that children's thinking about their experiences will move in a more structurally and qualitatively complex direction.

The major issue here is that the constructivist view recognises that an understanding of human development, and the contexts within which that development takes place over time, are more important than (but not opposed to) understandings about learning. The complex linkages between these has been well described recently by Deloache and Brown (1987), writing on the early emergence of children's planning skills, and the manner in which even toddler-aged children create problems to solve, as well as set about solving them. They observe that while developmental psychology was not well served in the past by ignoring young children's competencies, nor is it likely to be well served in the future by exaggerating those competencies, or by assuming a linear progression between early skills and later achievements.

As yet the constructivist view of early education (which reflects the cognitive-developmental emphasis) has paid little attention to computers. A recent constructivist text, for example, makes no mention of them in early childhood (DeVries, 1987). By default, therefore, there is a risk that programmes of early education will succumb to the "bag of virtues" strategy (so that software promising to develop "creativity", "independence", and so on is seen to be of unquestionable value); or reflect the "industrial psychology rationale" (promising achievement and success at an early age). Both these tend to see technological innovation as of intrinsic benefit to young children's learning (with a consequent emphasis on instructional strategies).

A constructivist perspective on computers for early childhood education has yet to be presented, but could be outlined as suggesting:

* that developmental advance involves structural change (altered ways of thinking about the world) rather than learnings which may be temporary and unrelated to real experience;

* that direct (sensory and concrete) experience of real objects is more likely to aid construction of cognitive structures than is interaction with "objects as represented on a computer screen";

* that any experience young children have is nevertheless capable of being integrated into their cognitive structures: the issue concerns what real meanings are in fact being developed (as opposed to facts being learned);

* that careful and sympathetic opportunities need to be provided for young children to discuss their activities with peers, and with others who are more experienced, in order to encourage them to reflect on their actions;

* that since meanings are constructed by individuals and their unique experiences, interactions between children and adults (perhaps including computer experience) are likely to be more beneficial than are those between children and computers with "instructional software";

* that projects which are "engaging of children's minds" (Katz & Chard,

1988) by relating a variety of different activities over extended periods of time (as opposed to being concentrated on specific learnings) are likely to benefit children cognitively as well as socially: computers alone can not provide such engagement over time.

Conclusion

While there is a genuine hope among some educators that computer usage will radically restructure the process and methods of education, and fears from others that it may very well succeed in so doing, it is unlikely that such an aspirations or fears can or should be held for early childhood education at this point. Nor does it seem likely that the situation will change quickly.

The evidence from both theoretical and empirical sources suggests that computers by themselves are not necessarily advantageous nor disadvantageous for young children. Thus, as with any new item of preschool equipment, it depends on the context within which the item is used, and on the manner in which the environment for learning and development is established by teachers and parents of young children. A number of observational studies will need to be undertaken before we can being to feel confident that we even know what variables to investigate in this regard.

Teachers' and parents' views of the place and value of computers have not been examined. Yet it is inevitably the case that adults' perceptions of computers, and their expectations for their use, will help to shape the way in which they do become used. The theme of this paper is that such an exercise requires some careful thinking about the model of education being promulgated when computers are advocated for young children. The suggestion here is that the cognitive-developmental perspective provides a starting point for considering the issues, and a framework within which the evidence itself, as it accumulates, can be evaluated.

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