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The Scientific World of Play and School: Primary Childrens' Uses of Hierarchical Concept Maps

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The premise of this paper is that children are active learners who engage in meaningful learning when a situation of interest presents itself. Children form mental models or personal constructs of how they perceive the world in which they live, the world does not create these constructs for them. As Kelly (1955) explains, constructs are individually built and "tried on for size" as one views the world of events. These constructs are sometimes categorized into groups of systems consisting of subordinate, coordinate, and superordinate relationships. They are used to forecast events and to assess the accuracy of the events after they have occurred. In the scientific world of play and school, children constantly test their interpretations of the world and revise their mental models or personal constructs as they experience and test alternative explanations throughout their lives.

The action research case study reports how young children can represent their scientific knowledge while simultaneously enhancing their literacy skills by using hierarchical concepts maps. Ausubel's (1968) cognitive theory of meaningful reception learning, Gowin's (1981) theory of educating, and a constructivist epistemology provide the philosophical and theoretical background upon which this investigation was designed and the results interpreted.

In our role as educators we may sometimes forget to include the experiences of our students when planning lessons. We may try to give students information without taking their world knowledge and experience into consideration. When subject matter is confined within a particular content area new information may be perceived as being artificial by those students who lack a situational context that links new ideas to existing knowledge (Alvarez, 1993). In these circumstances, students are given information without consideration of their world knowledge and experience. This notion of telling either by the teacher or the text is what Charles Gragg (1940) warns against in his essay "Because Wisdom Can't Be Told." His caution does not preclude learning under this mode, for it is possible that students can be given information that is learned through rote memorization. But such information may not be spontaneously retrieved in settings other than the one in which it was introduced (Bransford, Franks, Vye, & Sherwood, 1989). Whitehead (1974, p. 4) refers to this state of education as consisting of inert ideas - "ideas that are merely received into the mind without being utilized, or tested, or thrown into fresh combinations." To activate inert ideas, learners need to be provided with learning strategies and lessons that stir their imaginations and stimulate critical thinking in problem-solving contexts.

KNOWLEDGE ACTIVATION AND SCHEMA CONSTRUCTION

Mediated learning strategies that provide opportunities for the student to elaborate on the content of the text enhances comprehension (Alvarez & Risko, 1989; Reder, 1979, 1980; Risko & Alvarez, 1986). Educators and researchers have suggested numerous prereading instructional strategies to help students activate and use prior knowledge to aid comprehension (e.g., graphic organizers, thematic organizers, previews, advance organizers). The design of many of these preorganizers reflects Ausubel's (1959) definition of readiness and the purpose of their use is to create a mind set prior to reading.

Yet there is much evidence that good and poor readers do not use schemata appropriately or are unaware of whether the information they are reading is consistent with their existing knowledge (Bartlett, 1932; Bransford, 1979).

While schema theory explains how prior knowledge with a topic can be activated, it does not explain how a schema is constructed. As Bransford (1985) explains, schema activation and schema construction are two different problems. While it is possible to activate existing schemata of a given topic, it does not necessarily follow that a learner can use this activated knowledge to facilitate acquisition of new knowledge and skills. Students are often subjected to information that is course specific by which facts and ideas are given to them in the form of lectures and handouts with little emphasis on how they perceive its use in other subject areas. Students are encouraged to take this material and try to make sense of it. But if this new information cannot be related to prior knowledge or experience, students' efforts are directed to memorizing and compartmentalizing this information (see Potts, St. John, & Kirson, (1989).

Learning novel concepts requires the learner to connect new information to a congruent mental model. Mental models represent a person's construal of existing knowledge and/or new information even though this information may be fragmentary, inaccurate, or inconsistent (Gentner & Gentner, 1983). A person's mental model is a representation of a particular belief based on existing knowledge of a physical system or a semantic representation depicted in a text. Holt (1969, 1989) states that our mental models change when we explore the world around us, and create knowledge out of our own questions, thoughts, and experiences. In essence, a mental model is comprised of our organization of world knowledge and experience and represents our structure of reality (Alvarez, 1990). Problem-solving lessons and activities can provide learners with situations that aid schema construction which include critical thinking (see Johnson-Laird, 1983; McNamara, Miller & Bransford, 1991).

Critical thinking theory provides an explanation for activating existing schemata and for constructing new ones (Norris & Phillips, 1987; Siegel, 1988). Critical thinking provides a strategy (Siegler & Jenkins, 1989) for achieving understanding and can be accomplished by contrasting ideas and engaging in reflective thinking (Dewey, 1933). A reader can either weigh alternative interpretations, dismiss others, make a decision to evaluate multiple possibilities, or accept information as being reasonable. This process helps students to modify or extend their mental model, or existing knowledge base of target concepts.

CONSTRUCTING AND BUILDING THEORIES

Coming to know is the goal of the learner, while helping children learn how to learn is the objective of the teacher. The extent to which children "come to know" is determined by the interest and the facility with which they are able to integrate new information into existing knowledge structures (Stice & Alvarez, 1987). However, "knowing" and "learning" can be misconstrued by learners who rely on rote memorization techniques to store information particularly when subjects are taught as discrete units rather than integrated bodies of knowledge that can be related to one's life experiences (Alvarez & Vaughn, 1992; Donham, 1949; Erickson, 1984; Eylon & Linn, 1988; Giroux & Simon, 1989; Sarason, 1990). This type of presentation results in students mistakenly believing that success in school is equated with "knowing" a given body of knowledge of a subject rather than "learning" how this new knowledge can be related and used with their experiences and other subject disciplines both in-and-out-of-school (Alvarez, 1993; Alvarez, Binkley, Bivens, Highers, Poole, & Walker, 1991). This notion of having children actively participate in the learning process is an important aspect of constructivism.

Constructivism is based on the notion that children are actively engaged in building theories about the world and the way it works. This inquiry often is a natural process devoid of direct instruction that places children in the role of scientists who engage in experimentation and problem solving on their own. When in the classroom, the teacher can provide contexts that facilitate theory building by using meaningful materials and by making use of childrens' experiences (Chaille & Britain, 1991). However, while constructivism is a well-documented theory of knowing and coming to know, it is not yet a well-documented theory of teaching (see Fosnot, 1989; 1992).

It seems that an important role of an elementary school teacher when teaching content or subjects such as science is to aid students' ability to reflect upon what they know about a given topic and make available strategies that will enhance their conceptual understanding of text and science experiments. Developing metacognition, the ability to monitor one's own knowledge about a topic of study and to activate appropriate strategies, enhances students' learning when faced with reading, writing, and problem solving situations (see Baker & Brown, 1984). Metacognitive learning occurs whenever individuals are able to self-regulate and control their own learning when confronted with new knowledge. In order for metacognition to occur, one must have strategies for monitoring their understanding of a given topic. Recently, strategies have been reported in which students are active in constructing their own concepts (e.g., Driver & Oldham, 1985; Fosnot, 1989; Pines & West, 1986). One instructional strategy that may significantly enhance the young learner's ability to "know" (i.e., to categorize, organize and integrate new information) is hierarchical concept mapping (Novak & Gowin, 1984). A method designed to investigate the degree to which teaching and instructional learning practices are effective is action research.

ACTION RESEARCH

A major assumption of action research is that teachers will use data stemming from their findings for self-improvement because they consider it a relevant and important aspect of their instruction (Corey, 1953). The data derived from this type of research is emergent and requires the teacher to engage in reflective thinking as it evolves. This process is in direct contrast with those situations by which teachers and students are expected to use practices and methods that were initially tried by other teachers and students in other school systems under optimal experimental conditions.

In our studies, we have found that teachers are more self-assured when they have determined through their own investigation pertinent data to either support, alter, or disconfirm their newly learned practice (Alvarez & Vaughn, 1992; Alvarez, et. al., 1991; Alvarez & Risko, 1989; Alvarez, Risko, Waddell, Drake, & Patterson, 1988; Stice & Alvarez, 1987). Another principle of action research is that findings are not generalized to other students or teachers in other school systems, but are generalized to present students and to future students in forthcoming years who will encounter some of the same situations in which these studies were conducted. There is a feeling among those that have conducted action research projects that change comes from within a given classroom or school rather than mandated from outside sources (Alvarez, 1981; Boomer, 1987; Corey, 1953; Lewin, 1946; Elliott, 1991; Goswami & Stillman, 1987; Hustler, Cassidy, & Cuff, 1986; McKernan, 1991; Russell & Munby, 1992; Santa, Isaacson, & Manning, 1987; Winter, 1989; Zuber-Skerritt, 1991).

This change occurs in what Corey (1953) describes as vertical rather than lateral extensions of generalizations that are prevalent in fundamental research practices. These vertical generalizations aid the teacher in improving his instruction and to reach conclusions from which these ideas have their greatest impact on students that he will be teaching in the future. For example, teachers have informed us that they continue to teach hierarchical concept mapping to their students and show us examples of their students' mappings. They convey that their use of concept maps have occurred in a variety of settings and lessons and are evolving with respect to purpose and function as each academic year ensues. Likewise, students continue to use concept mapping in their learning of new information. Within this paradigm, the role of the societal and school curriculum are interrelated, and play an important role when a learner is confronted with new information. Children acquire much scientific and technical knowledge from their contact with the social and physical environment (Ausubel, 1968, Kelly, 1955).

SOCIETAL AND SCHOOL CURRICULUM

Societal and school factors are complex, interrelated, and interactive entities that influence the education of students. Societal factors include that portion of a person's education acquired outside the formal classroom setting (see Cortes, 1979, 1981, 1986). It comprises the informal curriculum of home, neighborhood, community, and society that combine to educate each individual. School factors focus on formal in-school functions such as curriculum, school organization, counseling, assessment, teacher expectations, behavior, and so forth. Being aware of the sociocultural context in which students live help the teacher to make learning a meaningful connection between the classroom and the student's world environment (Alvarez, 1993;

Alvarez et. al., 1991; Donham, 1949; Erickson, 1984; Eylon & Lynn, 1988; Sarason, 1990).

Disparity Between School and Home Learning

Much school learning consists of rote memorization of facts with little emphasis on meaningful interpretations. For example, students are often asked to solve scientific problems and conduct laboratory experiments in a rote rather than in a meaningful way (Novak, 1990, 1988, 1987). Often science knowledge is assumed to be absolute and students are viewed as passive recipients of information (Driver, 1987). In such instances, reading assignments are given, lessons are reviewed, and question-answering is equated with producing "right answers." Under these circumstances, knowledge construction is reduced to factual knowledge production with little regard for critical thinking, problem solving, or clarifying misconceptions.

Texts are often written to support acquisition of factual knowledge. The language of the textbook or laboratory manual is often vague with ill-defined concepts or with lists of facts that are not situated in a context that encourages students to relate new concepts to their prior knowledge. Seldom are these facts and ideas related to students' everyday experiences or to other disciplines (Donham, 1949; Erickson, 1984; Eylon & Linn, 1988; Sarason, 1990; Schwab, 1976). Further, Novak, Gowin, and Johansen (1983) show that students lack or misconstrue links between text concepts resulting in a failure to assimilate and accommodate new knowledge in their cognitive structure.

We offer a window through which an instructional practice such as concept mapping can be used to enhance literacy and conceptual learning with young children that filters in both their societal and school contexts in which they are significant members. Our perception of concept mapping is one in which this strategy invites questions from both the teacher and the student rather than an exercise in reinforcing or reaching "correct answers." Our concern that children have become dominant question-answerers instead of question-askers is founded upon our work with teachers and students in a variety of settings.

We have found that where teacher talk and questions tend to dominate in-school experiences, teachers have an expectant answer in mind. To illustrate, Christopher (age 4) raised his hand to respond to a teacher's question and was called upon. After he gave his answer, the teacher stated: "That is correct," and proceeded to elaborate upon his answer. When she had finished, Christopher asked her: "If you already know the answer, why did you ask me?" This disparity in question/answer relationships is explained, in part, by the manner in which literacy development occurs in the home versus a school-type learning environment (see Chapman, 1986; Doake, 1986; Fagan, 1987; Goodman & Haussler, 1986).

Spontaneity is a key ingredient that separates home from school learning. Children use language at home to express their thoughts and are concerned more with meaning rather than form. Home-type learning allows for knowledge responsive to the child's curiosity, interest, and a need to understand and communicate ideas that emerge from informal events. Authentic questions and problems are discussed and solved as the need arises. Conversely, structure, form, rules, and memorization tend to be associated with school-type learning. This occurs, in part, because teachers follow guides within published reading materials that contain answers corresponding to predetermined questions. Questions with preconceived answers serve as artificial exercises in which both teachers and students exchange quips in a mechanical rather than a thoughtful dialogue.

The following case studies are presented to illustrate how hierarchical concept mapping can serve as an aid to theory building and construction within the context of childrens literacy and scientific learning in home and school environments.

KINDERGARTNERS' USE OF CONCEPT MAPS TO ENHANCE LITERACY AND CONCEPTUAL KNOWLEDGE

After demonstrating how to construct concept maps with her 24 kindergarten students, the teacher asked her students to select a topic and to make a concept map. Upon completion, ten kindergarten students were randomly interviewed. Each was asked to read the concept map that they had constructed during the morning lesson and to read a map that the interviewer had selected from a previous day's assignment. Every student was able to read, discuss, and elaborate upon their concept maps. The teacher gave additional insight into the ways in which concept maps aided young children's curiosity.

Interviewer: What do you find most helpful about concept maps?

Mrs. S.: It really lets me see immediately where the children are not understanding a relationship between one concept and another...and it helps them see that once I show it to them they say 'Oh.' So even at this early age you can see misconceptions early in order to answer and set that misconception correct.

Interviewer: What are some of your general impressions about concept mapping?

Mrs. S.: They're a lot of fun to do. The children are asking to go to the library. They want to do more research. They want to get more books. They want more information so they can add that to their maps and that's the thrilling part. This has happened two days and the first day they didn't do that; this is the third day we've done the concept maps and yesterday they started asking me and today the whole class really wanted to go to the library to research their own particular interest.

Interviewer: What do the children themselves tell you about concept maps? Do they find them difficult?

Mrs. S.: They haven't really said they were difficult or hard. They have enjoyed doing them...We had done some work on maps before on mapping a room. They immediately related concept maps to the maps of the room. We hid some buried treasure and drew maps to try and find it. So that was fun. This just really excited them to think that you could do other kinds of maps.

Interviewer: Do you find that they are starting to organize their ideas better as a result of their constructing concept maps?

Mrs. S.: Yes, when we did the one about the animals - that came from them. We had done our morning story and as we talked about the animals [in the story], and the dogs and cats they started saying 'What kinds of things are alike about dogs and cats?' 'What things were different?' They brought the concepts that were the same about the two animals in the middle, and the things that were opposite - that were not common to both animals - to the sides. So that was a lot of fun to do that and it was real interesting to see that they understood that much.

Interviewer: Can you relate concept mapping to a writing activity?

Mrs. S.: Yes, we haven't gotten that far yet, but I would like to see after we do more of our concept maps and get to a point where they would have it finished, then they can write a paragraph or simple sentences about their concept maps. Another thing that's been interesting is that they are zeroing in on what a concept is and what a linking verb is. They'll ask each other is that a concept? Close your eyes can you see it? 'Yeah, I can see swimming'.

Interviewer: That's what that boy said this morning. It's an idea that makes you think of...

Mrs. S.: [Spontaneous interruption] *You can close your eyes and see it*

in your mind [Italics for emphasis]

Interviewer: Yes, you can see it in your mind. That was interesting.

Mrs. S: And it's interesting to hear them using the language. To hear them talking about concepts. Is that a concept? [Laughter]

Mrs. S., was able to look at the children's concept maps and determine if there were any misconceptions in relating their concepts. Children asked to go to the library, on their own volition, to find our more about their self-selected topics. They would then come back from the library and either add or delete information on their concept maps. They were not restricted to waiting until their regularly assigned day to visit the library. These children, at an early age, were able to think, organize their ideas, and express their thoughts and feelings.

To illustrate how these kindergarten children constructed their knowledge about a self-selected topic, Amie's concept map is presented in figure 1 as an example.

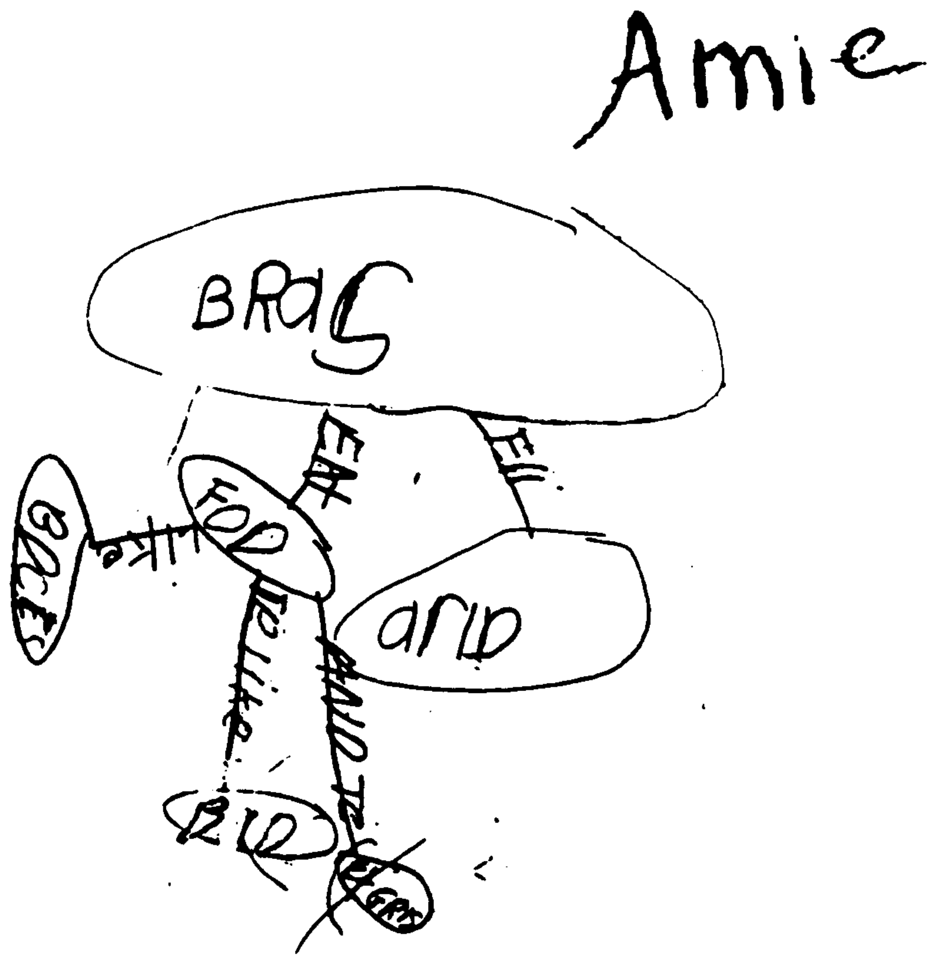

Figure 1. Amie's concept map about birds.

Amie's map is hierarchically represented depicting the kinds of food that "bras" (birds) eat and the fact that they "fli arid" (fly around). In reviewing her map with the teacher, the teacher sees that Amie has included "grass" as a food in which birds eat. She asks Amie, "Do birds eat grass?" Even though it is a natural assumption for children to believe that birds eat grass in light of the fact that they see birds pecking at the grass, Amie replies, "I don't know." The teacher asks her "How can we find out?" Amie says to the teacher, "I will go to the library." Without hesitation, Amie leaves the classroom and proceeds to the library. Amie shows the librarian her concept map and asks her about books that tell what birds eat. Together the librarian and Amie review books on birds. Amie finds that birds do not eat grass. She immediately puts an "X" on her map where she has written that "bras et gris" (refer to figure 1). The librarian constructs the map in figure 2.

Figure 2. Revision of Amie's map by the librarian.

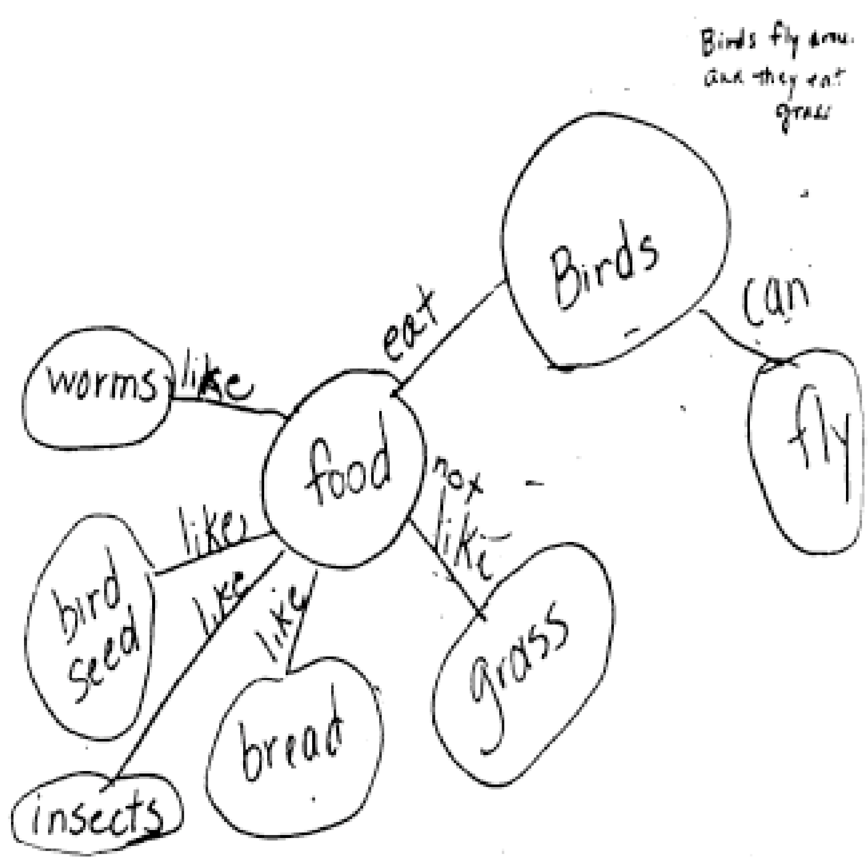

Figure 2. Revision of Amie's map by the librarian.

After reviewing this map together, Amie reconstructs her map (see figure 3). In so doing, she reflects upon her original map and reorganizes her first version.

Figure 3. Amie's reconstruction of her original map.

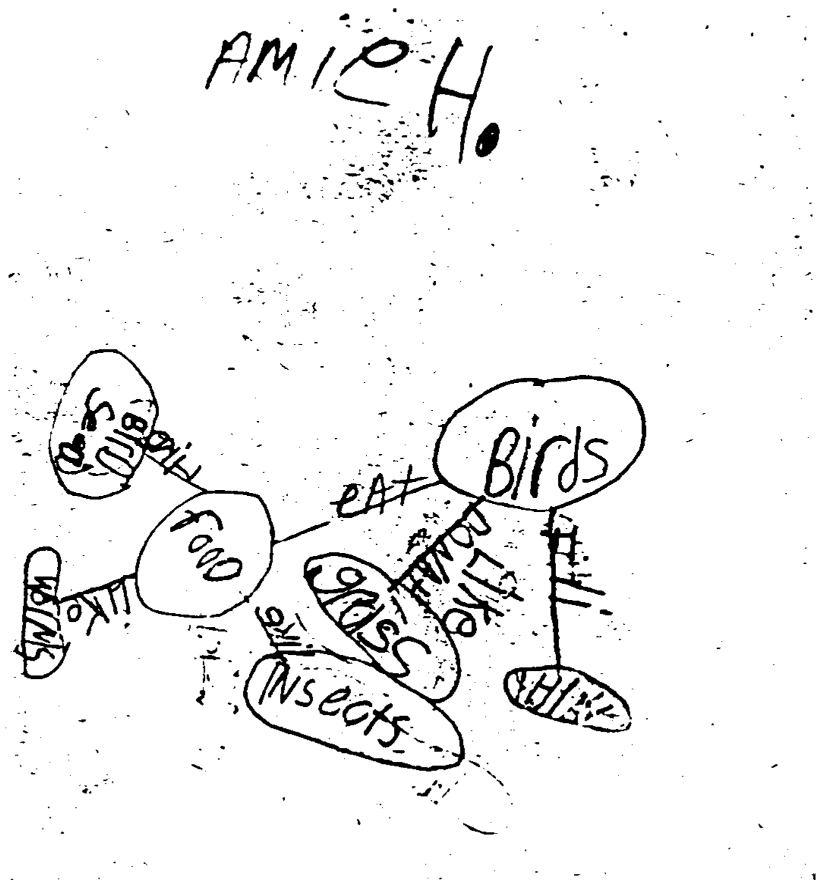

Figure 3. Amie's reconstruction of her original map.

In addition to including the types of food she had stated earlier ("bdces" - bird seed, "brd" - bread), she has added other kinds of food: worms and insects. She has also written on her map that "Birds do not like grass." Not only has her literacy skills improved, but her knowledge about what birds eat has expanded. This new information was learned not through telling by the teacher, but in a nonarbitrary mode that allowed Amie to engage in her own problem-solving format.

The above encounter with Amie and her teacher shows how mediated learning can occur through the use of concept maps. Theory building is enhanced as a result of revising one's mental model about what birds eat. It also illustrates an important aspect of intelligence. Intelligence is not what you know, but what you do when you don't know and want to find out. In this instance, Amie demonstrated her intelligence by resolving her uncertainty about the feeding habits of birds when she consulted with the librarian and reviewed books about birds. This new learning occurred not by telling, but by having the student engage in an active learning episode that allowed her to create her own learning context. Mrs. S., felt that concept maps help her students to organize their ideas of topics, and she saw positive changes in students understanding of conceptual relationships.

TRACING CHRISTOPHER'S LITERACY SKILLS WITH CONCEPT MAPS

Three concept maps are presented of one child's progression to show how literacy skills can be developed through their use. The first began as a preschooler at age 4 years, eight months. A conversation was conducted with Christopher for the purpose of analyzing Anglin's (1977) method of classification of children's concepts and comparing it to Novak and Gowin's (1984) method of depicting concepts hierarchically (see Alvarez, 1990). This conversation portrays how both of these methods can be used to reveal a preschool child's thought processes with a topic about dogs. Probes were used to elicit more information from him.

Me: What do you know about dogs?

C: Well, they ruff and they eat dog food.
They eat bones and have sharp teeth.

....

Me: What is a dog?

C: It's an animal. They stand up on their two legs.

....

Moments Later

Me: What is a dog?

C: A dog is an animal.

Me: What else?

C: Well, he's an animal and animals turn into animals, And dogs can be
named anybody,. Like other people's names. Like dogs eat bones
not like the dinosaurs. And dinosaurs don't eat stuff like that.
And dinosaurs drink water like dogs. And dogs could see they have
eyes like other people too. Dinosaurs have eyes too like dogs.
But dogs and dinosaurs are different. They're a little the same,
they are both animals, and different when they're both - dinosaurs
roar and the doggies ruff, bark, and dogs don't stand up like other
people they stand up like this [gets on all fours].

Me: Like what?

C: On their feet like this.

Me: How many feet do they have?

C: Four [counts] one, two, three, four.

Me: Yes.

C: And we have two like the Tyrannosaurus Rex cause he had two feet
just like man.

Me: Is man an animal?

C: Un humm. Yes.

The conversation with this child indicates that he knows that dog is a subordinate concept and can be categorized under animal (a superordinate concept). He knows that dogs eat dog food and bones, and that they have sharp teeth. He compares dogs, dinosaurs, and man. All three have eyes and therefore can see, and are animals. Dogs and dinosaurs also drink water. He contrasts dogs and dinosaurs by stating that dogs ruff - bark, while dinosaurs roar; and, that dogs stand [walk] on four legs while the Tyrannosaurus Rex stands [walks] on two legs. His comparison with dinosaurs indicates that he has a general knowledge of dinosaurs and a specific reference with the Tyrannosaurus Rex, which is different from the dinosaurs that walk on four legs and are plant eaters. After a short interval, when he is again asked "What is a dog?" he reiterates the superordinate concept "animal" and is able to reflect and contribute more information to the additional probes.

Two visual displays are presented to show how children can reveal their mental models of thinking in a hierarchical structure. The first display (figure 4) represents this child's responses using Anglin's method; the second, Novak and Gowin's (see figure 5).

The superscripts correspond to the question number and the child's response. The responses are categorized as being either superordinate properties or subordinates.

Figure 4. Anglin's classification method.

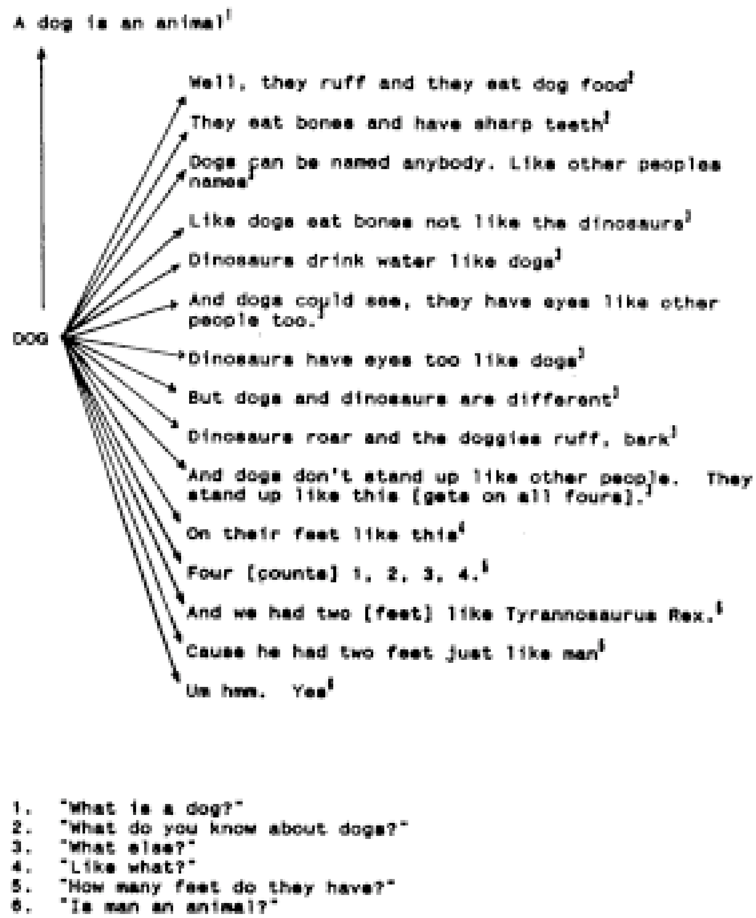

Figure 4. Anglin's classification method.

Figure 5 is a concept map that represents a hierarchical representation in a different fashion. The broken lines on this map are cross-links that show how one part of the map is related to another. They also serve to illustrate comparison-and-contrast, such as that dogs and dinosaurs both drink water and have eyes, while dogs eat bones and dinosaurs do not eat bones.

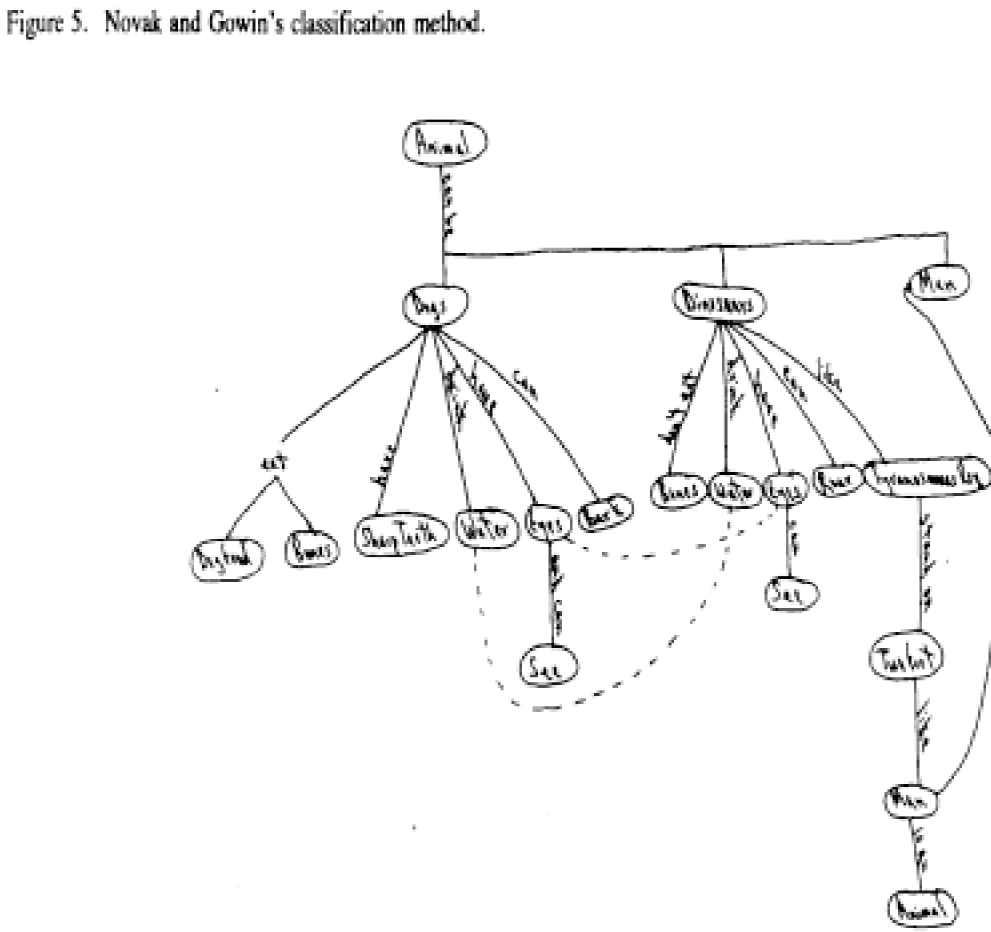

Figure 5. Novak and Gowin's classification method.

While both methods classify a child's revelations with a topic, Novak and Gowin's (1984) concept mapping procedure seems to portray the information in a format that offers a child a clearer perspective from which to learn conceptual relations and develop literacy skills (see Alvarez, 1990; Alvarez, Risko, Waddell, Drake, & Patterson, 1988; Stice & Alvarez, 1987). In this case, the child was asked to read from the concept map and point out the comparisons and contrasts between the dog and the dinosaur. The words had special meaning since they were generated from his knowledge and therefore constituted a form of language experience in learning.

The second example portrays Christopher's construction of a concept map while in first grade (see figure 6). The map is divided into two categories of dinosaurs: meat eaters and plant eaters.

Figure 6. Christopher's concept map on dinosaurs as a first grader.

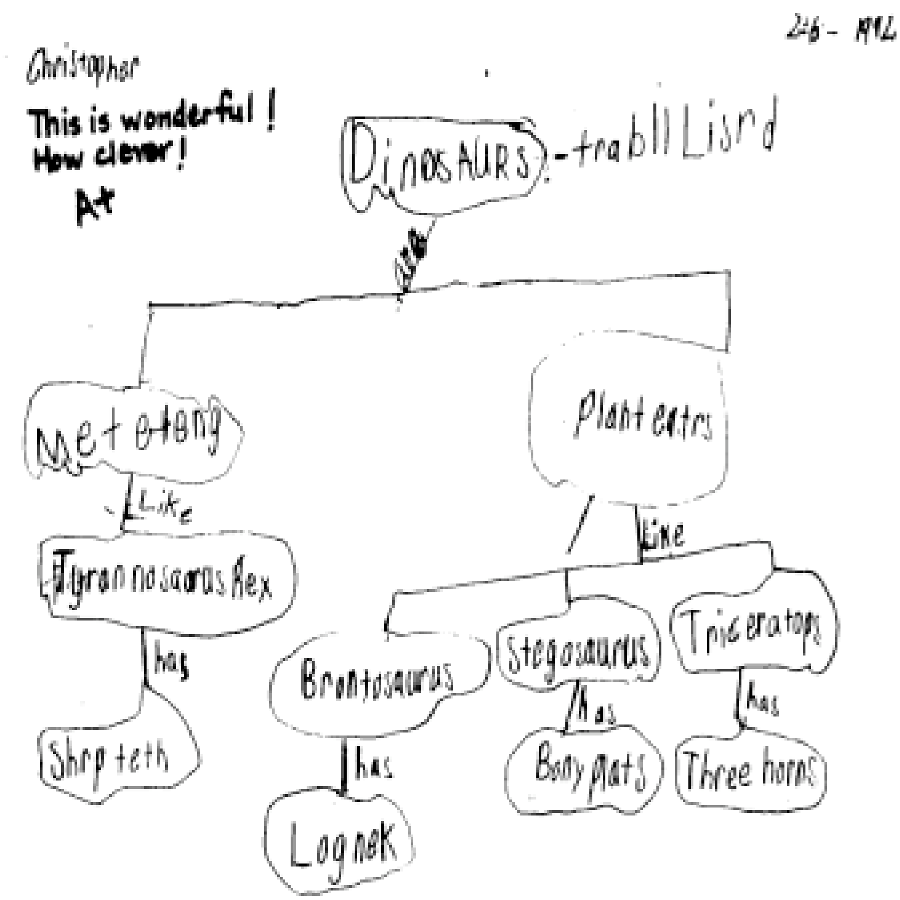

Figure 6. Christopher's concept map on dinosaurs as a first grader.

When constructing this map Christopher used invented spellings, a common occurrence among emergent writers (refer to Amie's map in figure 1). However when he came to writing the names of the dinosaurs he began struggling with their spelling. When he was asked why he didn't look up the correct spelling from the books he had on dinosaurs, he replied "I want to spell words like big people." He was advised that "big people" look up words when they are not sure of their correct spelling. Christopher was then asked to consult his books on dinosaurs to locate the correct spelling. In so doing, this searching for information introduced him to the notion of using books as reference tools.

Our third example shows how Christopher has evolved in using his concept map as a template from which to write an essay. While in the second grade, the class was assigned to write an essay entitled "My Invention." Christopher decided that he would write his essay about the invention of a soccer thrower. We asked him to construct a concept map before writing his essay (see figure 7).

Figure 7. Christopher's concept map in preparation to writing his essay.

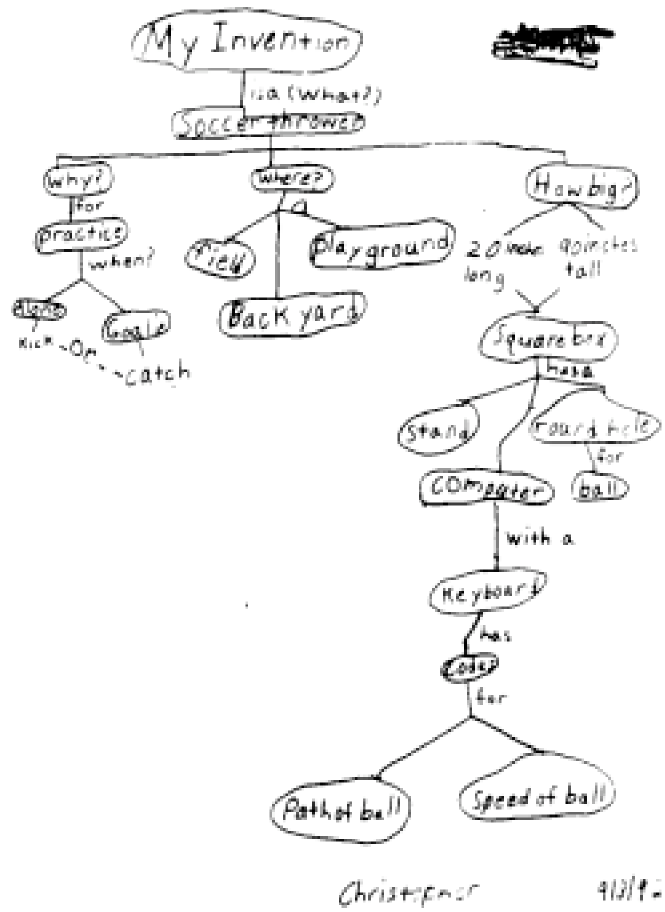

Figure 7. Christopher's concept map in preparation to writing his essay.

In this map, he included the "What?", "Why?", "Where?", "When?", and "How?" in organizing his ideas for a soccer thrower. His ideas are depicted hierarchically with cross-links signifying in which circumstances the soccer thrower could be used. These ideas served as a template from which to write his essay which is shown in figure 8.

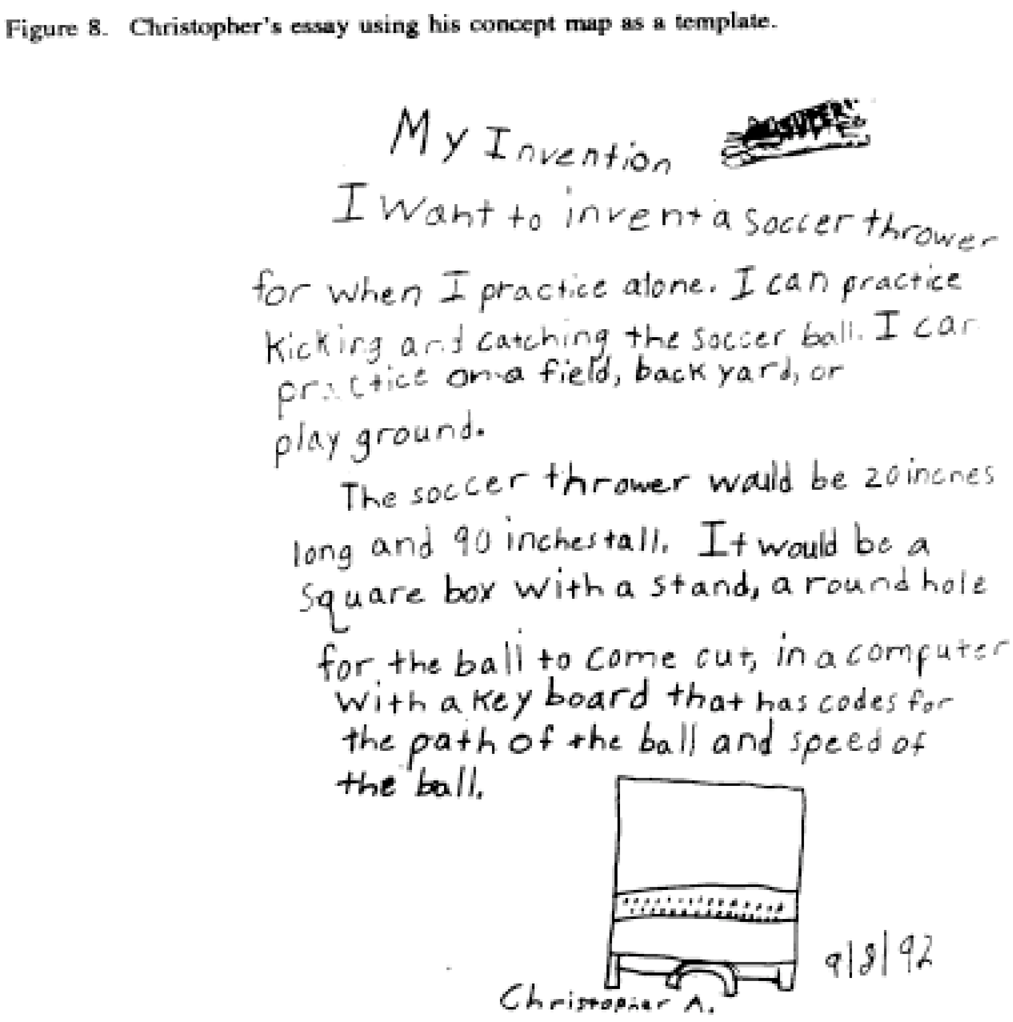

Figure 8. Christopher's essay using his concept map as a template.

My Invention

I Want to invent a soccer thrower for when I practice alone. I can practice Kicking and catching the soccer ball. I can practice on a field, back yard, or play ground.

The soccer thrower would be 20 inches long and 90 inches tall. It would be a Square box with a stand, a round hole for the ball to come out, in a computer with a Key board that has codes for the path of the ball and speed of the ball.

9/8/92

Christopher A.

Figure 8. Christopher's essay using his concept map as a template.

His essay is well-organized and clearly demonstrates the uses of the intended invention. He has also opted to include a drawing of the soccer thrower. In reviewing the three concept maps presented, a pattern of literacy emerges from initially representing what this child revealed about his understanding of dinosaurs and man, to his depiction of comparing and contrasting dogs and dinosaurs, to his classification of dinosaurs as meat or plant eaters, to his own interpretation of an invention described as a soccer thrower. In each of these visual representations, this child's societal and school experiences are displayed in the events to which they are revealed.

CONCLUSION

Concept maps served as an evaluation instrument for both the teacher and the student in determining how well ideas were represented among the component parts. Kindergarten students achieved a certain degree of self-empowerment (a notion that one can cause his or her own learning while trusting others in the process) when they corrected their scientific misconceptions. Together, the teacher and the student, were able to resolve uncertainties or misunderstandings and make the educative event a meaningful learning experience. Responsibility for learning science concepts took on a new dimension through the use of hierarchical concept mapping. Students recombined facts into ideas, and misconceptions about scientific concepts were resolved. Misconceptions cause dissonance and resolving these inconsistent notions through negotiated meaning is the essence of new learning.

Hierarchical concept mapping is a way to help students penetrate the structure of knowledge they seek to understand. Being able to get the right answer is sufficient in many school evaluations upon which grades are based, and too often only rote recall is needed to answer questions. Teachers when versed in concept mapping seem to be receptive to this learning strategy in order to achieve meaningful rather than rote verbatim learning, and see this strategy as an independent learning aid to be used by the student (Novak, 1990; Novak & Gowin, 1984; Novak, Gowin, & Johansen. 1983). A conceptual change approach to teaching should include explicit ways for students to become aware of their own beliefs and to come to understand the nature and construction of knowledge (Bransford & Nitsch, 1985; Brown, 1975; Fosnot, 1989; Siegel, 1988). Concept maps provide the learner with this type of a metacognitive tool by which facts and ideas can be learned meaningfully through reflective thought.

If we expect critical thinking occur, we need to provide learners with problem-solving lessons in meaningful learning contexts. These learning contexts become meaningful when new information is linked to existing concepts, and when learned, becomes incorporated (integrated and related to other knowledge sources in memory) rather than compartmentalized (isolated due to rote memorization). This notion is consistent with Ausubel's (1968) theory of learning, Gowin's (1981) theory of educating, and Gragg's (1940) warning that "wisdom can't be told."

The language of children reveals their understanding of how the world works and reflects a mental model of how they perceive the workings of the world (Donaldson, 1978; Garnham, 1987). A constructivist's view of knowledge making is based on the individual actively constructing the form and content of his or her own experience (Cofer, 1977). In this view, cognitive structures are not fixed but vary with the development and experience of the individual. The case studies presented indicate that children are actively constructing meaning when they relate an event/object that is part of their daily lesson to their everyday experience and world knowledge.

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