

AN INVESTIGATION OF THE PROBLEM-SOLVING KNOWLEDGE OF A YOUNG CHILD DURING BLOCK CONSTRUCTION

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Abstract: This is an investigation of the problem-solving knowledge demonstrated by two five-year-olds during block construction. Behavioral and verbal indicators for declarative, procedural, schematic, and metacognitive knowledge were used to identify the child's problem-solving knowledge as they solved construction problems. Children were videotaped during month-long free play sessions using specifically-designed Arcobaleno blocks. Results indicated that although both children were successful solving the construction problems, each child demonstrated the use of different knowledge in their play. Most noteworthy, their use of metacognitive knowledge was especially obvious as they naturally shared their knowledge with their peers.

Early childhood educators have long emphasized the importance of block construction in early childhood classrooms. With special emphasis on the cognitive and social significance, theorists and educators alike have strongly advocated the importance of block play and its aid in developing problem-solving skills (Cuffaro, 1991; Gura, 1992; Vygotsky, 1976). Mathematics educators have agreed, acknowledging that "the ability to look at situations geometrically, spatially, and analytically enhances understanding and problem-solving success" (Lappan, 1999). Because the foundations of geometric thought begin at a very early age and because of our dismal performance on recent international and national tests (TIMMS and NAEP), geometry, spatial thinking, and problem solving have become a focus of mathematical teaching even at the pre-kindergarten level (Clements, 1999; National Council Teachers of Mathematics, 1999). Although problem solving is often mentioned as a natural outcome of block construction, it is not clear what type of problem-solving knowledge young children naturally demonstrate when constructing with blocks.

Objective

This study was designed to investigate the problem-solving knowledge of two young children during block construction. To accomplish this purpose, behavioral and verbal indicators of metacognitive, declarative, procedural, and schematic knowledge were used to identify children's specific knowledge in month-long free play sessions.

Theoretical Framework

Cognitive development research suggests that young children's cognitive performance is "profoundly variable and that performance variability is a reflection of important properties of their knowledge." (Sophian, 1999, p. 19). Thus, observing performance in context is necessary over a period of time to make accurate assessments of children's understanding. In addition, informational processing proponents view the effective use of specific processes and operations as necessary for successful problem solving. Hamilton and Ghatala (1994) explain four types of knowledge that contribute to

the effective solution of problems. Declarative knowledge is the domain-specific, verbalizable knowledge that increases the number of cues for accessing relevant knowledge. Procedural knowledge involves effective strategies for solving problems. Schematic knowledge is the larger chunks of related thematic knowledge within the content area. Metacognitive knowledge is the planning and monitoring of problem-solving attempts. While declarative, procedure, and schematic knowledge alone cannot ensure effective problem solving, there must be an awareness of knowledge about one's own knowledge and the active monitoring and regulation of learning (Baroody, 1993).

Method or Mode of Inquiry

This is an observational case study of two five-year-olds, one female and one male, during block play. Both Wesley and Aimee* were members of a summer preschool program in an urban southwest city in the United States. Both children demonstrated success on the reproduction and visualization problems after free play. Their block play was videotaped at three different times: (a) during the completion of visualization and reproduction problems before free-play sessions, (b) during month-long, free time block-building sessions with peers, and (c) during the completion of visualization and reproduction problems after free play sessions.

Arcobaleno blocks (Learning Materials Workshop Blocks designed by Karen Hewitt) were used for this study because of their special spatial relationships. The beveled, curved blocks are twelve half circles with six different radii in six different colors; their design increased the number of aesthetic variations and possible geometric patterns. Six construction models specific to Arcobaleno blocks and rated from easiest to hardest were used for the visualization and reproduction problems. Each problem or model had a name that was easily identifiable to young children: A "House", B "Caterpillar", C "Hut", D "Snake", E "Bowl" and F "Snail". To create each model, children had to use the correct blocks, place them in the correct order, and balance them in unique ways. The same problems were used before and after the free play sessions. Visual models of the problems were then posted near the free play construction sites for reference.

Data Sources and Evidence Collected

The visualization and reproduction problems required children to identify specific drawings of block structures that they believed could be made with the Arcobaleno blocks and then to reproduce them using a completed model as a reference. When a model became too difficult, the next model was attempted, and when that model proved to be frustrating, the task was discontinued. The number of correct solutions (0 to 6 models) as well as the time required for building each model were recorded.

During the free play sessions and the visualization and reproduction tasks, all experiences with Arcobaleno blocks were videotaped. Tapes were transcribed specifically noting children's play behaviors and verbalizations. Written and validated during a pilot study of ten children during block construction (Oto, 1997), specific behavioral and verbal indicators for declarative, procedural, schematic, and metacognitive knowledge were used to identify children's problem-solving knowledge as they constructed with the

blocks. Each videotape was viewed independently by at least two researchers and behaviors or verbalizations labeled as “demonstrating declarative, procedural, schematic, and/or metacognitive knowledge” with an initial inter-rater reliability of more than eighty-five percent.

Results

The cognitive performances of both Wesley and Aimee were variable as expected; however, during the final reproduction problems, both children completed most reproduction problems with little error. During the initial and final reproduction problems, Wesley built all models correctly with only a few variations. However, the initial building construction took three times longer than did the completion of the final models. Aimee, on the other hand, experienced no success on any of the models during the initial task and yet completed five of the six models with little error during the final reproduction. In contrast to Wesley, Aimee’s final building time was twice as long as her initial building time.

During the free play sessions, Wesley spent half of the time building with the Arcobaleno blocks. Nearly all of that time, Wesley worked directly with one or more of his peers asking them to “make it like this “ or “look” as he demonstrated the procedure. Aimee spent one fourth of the free play time building with the blocks. Of that time, half of the time was spent socializing with peers about the blocks, with the remaining time spent in observation of other’s work and independent building. Both children’s verbalizations and behaviors indicated that they had some declarative, procedural, and metacognitive knowledge. Indicators for schematic knowledge were few in number.

Declarative Knowledge. Both children talked about the blocks using a variety of descriptive terms. Aimee’s language was quite specific during her self-talk and her discussions with peers. Her verbalizations indicated that she had some declarative knowledge about the blocks and their positions. Wesley, on the other hand, easily recognized when one of his friends had the blocks turned incorrectly or when the edges had the wrong orientation. Although he did not verbalize the information, his demonstrations along with “not this.... this” terminology indicated that he used his declarative knowledge about the position of the blocks in space and balancing principles.

Procedural Knowledge. Trial and error was easily the most frequent procedure used by both children. Wesley was very systematic in his approach, while Aimee was more random. In one particular session, Wesley spent more than an hour enlisting peer’s help in making a symmetrical wave creation. In another session, he worked on one of the reproduction tasks that were difficult to balance. He systematically tried it three times one way; it collapsed. Three times another way; it collapsed. He then moved one block, tried it three times, it stood! Aimee’s strategies were very interesting. She seemed to place the block in a boundary pattern rather than systematically placing the blocks in order. Her procedures were place the outside block, place the block opposite in position, and then place the block in the center. She continued that type of “pattern” building throughout the sessions.

Metacognitive Knowledge. Most noteworthy, children’s use of metacognitive knowledge was indicated during both the free play sessions and the reproduction

tasks. Wesley's plans were systematic and flexible enough to adjust when he found problems. During his free time, he continually monitored his building by frequently checking the posted visual models. When he worked with peers, Wesley always took the initiative and suggested the division of labor. He also spent most of his time demonstrating to others how to make the pictured reproductions, even saying, "just do it like me.... watch." Evidence of his planning was obvious by his behaviors. Aimee, on the other hand, planned "out loud." She constantly verbalized her plan of reproduction such as "I will make this (pointing to the picture of models)" and "I'll do this once more" or "I won't do that one. It is just too hard!"

Interpretations

Several interpretations can be made from this data. First of all, the two young children in this study demonstrated a wide variety of problem-solving behaviors or verbalizations. Although each child verbalized or behaved using different problem-solving strategies or connections, each one demonstrated informal problem-solving knowledge that far exceeded our expectations. Second, both Aimee's self-talk as she monitored her constructions and Wesley's step-by-step demonstrations while he directed his peers indicated that these two five-year-olds had an amazing, albeit incomplete metacognitive knowledge. Both Wesley and Aimee reflected on their constructions comparing their constructions and commenting on their relationship to the pictures. Third, both subjects initially used trial and error procedures as they built. As they became more proficient, however, Aimee systematically placed blocks by first building boundaries while Wesley seemed to identify "up-down" and "curvy-straight" patterns as he placed them sequentially. Finally, although children demonstrated the use of problem-solving knowledge, their skills were frequently a random occurrence and often inconsistently applied. Because early mathematical cognition is full of variability, teachers need to be aware of a young child's informal knowledge and build on that knowledge as they teach a more formal approach to mathematics. Sophian (1999) describes the young child as "fertile ground for instruction," a statement that is supported by this study.

Note: *Names of children have been changed to ensure privacy.

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