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USING CONCEPT MAPPING TO FACILITATE METACOGNITIVE CONTROL IN PRESCHOOL CHILDREN

Amy E. Cassata, Lucia French
Warner School of Education and Human Development, University of Rochester, Rochester, NY 14627, USA
Email: acassata@warner.rochester.edu

Abstract. The purpose of this study was to explore the ways in which a concept mapping task could enhance the learning experience of preschool children by facilitating metacognitive skills involving planning, prediction, correcting errors and evaluating progress. Specifically, this study used discourse analysis from transcribed videotapes to explore child-adult interactions in three small groups as each group engaged in building a concept map about pumpkins. The targeted observations specifically focused on (1) identifying scaffolding of metacognitive control by adults during the activity and (2) seeking evidence of regulation-in-action evidenced by children's talk and behavior. Findings suggest that the extent to which preschoolers are able to engage in metacognitive processes depends on the manner in which the activity is framed and structured by the adult overseeing the activity, highlighting the importance of the social context in fostering the effective use of "metacognitive tools."

1 Introduction

Concept maps have been described as "metacognitive tools" (Mintzes, Wandersee & Novak, 1997) that encourage students to think reflectively about what they know through the visual representation of concept meanings and relationships. The process of creating and modifying a concept map involves making decisions about the different ways concepts are related to one another, leading the individual to reflect on prior knowledge as it relates to new material (McAleese, 1998), as well as engaging in "control" processes of planning, monitoring progress, and evaluating goal attainment as the map is constructed (Brown, 1987). Metacognitive processes, enabling the learner to flexibly and selectively coordinate knowledge, lead to a deeper level of understanding by making students responsible for their own learning (Georghiades, 2000).

Improvements in self-reflection and strategic action following concept mapping instruction have been reported by students in college (August-Brady, 2005), high school (Chularut & DeBacker, 2004), and primary school (Stow, 1997). Figueiredo, Lopes, Firmino and Sousa (2004) demonstrated that some preschool children are able to recognize a concept map as a scheme that helps them "know what they know." Beyond this, however, research has not considered whether concept mapping activities can facilitate young children's metacognitive control. It is known that during problem-solving activities, preschoolers are able to exhibit "regulation in action" by stating goals, planning, "thinking aloud," and detecting and correcting their own mistakes (Cox, 1994). Hence, preschoolers' talk and behavior while creating and revising a concept map may reveal the active use, monitoring, and evaluation of knowledge that is not otherwise easily expressed by young children with developing language skills. The research reported in the present study investigates preschoolers' use of metacognitive control skills within the context of a small-group concept-mapping task.

1.1 Concept Mapping as a "Metacognitive Tool"

Concept mapping provides children opportunities to both monitor their own knowledge and control their thinking. In planning to build a map, the learner must reflect on prior knowledge, perhaps by asking "what do I know about…?" (McAleese, 1998). Children must make important planning decisions about which concept will be the focus of attention, where the concept will be placed on the map, and in what ways concepts may be linked to one another. By rearranging items on the concept map and hearing classmates' thoughts about conceptual relationships, children are able to consider multiple perspectives and multiple ways that the final goal may be reached. Finally, by "telling the story" of the map by following the path of the links, concept maps provide a powerful tool to check "sense-making," as well as a visual means to repair or make corrections if an error is detected (Gallenstein, 2005).

Although the ability to read and write is fundamental to understanding symbolic word meanings present in traditional concept maps, the task can be modified for children with developing literacy skills (Gallenstein, 2005). Rather than using words alone to represent concepts, concrete objects, pictures of objects, or picture word cards can be substituted in order to provide children the opportunity to participate at an appropriate developmental level. By

physically manipulating the concepts on a felt or magnetic board, and making connections using string, pipe cleaners, or arrows, children learn to organize their thoughts in a visual and kinesthetic way (Gallenstein, 2003).

1.2 Concept Mapping as Social Process

A great amount of adult guidance is necessary in order for very young children to effectively engage in a concept mapping activity. Limited verbal language and social skills sometimes make it difficult for young children to work cooperatively, share ideas with others, and take multiple perspectives (Fleer, 1992). In order to reduce task complexity to allow for children's full participation, individuals in a monitoring or overseeing role may structure the task by providing both external supports (limiting group size, reducing the number of concepts introduced) and regulatory supports (talking about each concept to elicit prior ideas, modeling metacognitive talk, reminding children of their ideas and questions, and teaching strategic behaviors).

In addition to structuring the activity and reducing complexity, the role of the teacher also involves helping the child understand the goals of the concept mapping activity and why certain actions are important in attaining those goals. For example, in selecting concepts to add to the map, the child must share in the intention to "make sense" of one or more concepts in order for the selection to be meaningful (McAleese, 1998). Likewise, the acts of placing concepts in relation to one another and specifying links between unconnected concepts require that the child thoughtfully consider the ways that new ideas relate to what is already known. The challenge for the teacher is to provide the kinds of support that are most conducive to children assuming metacognitive control, in which children both have opportunity and are motivated to direct their own mental activity.

2 Method

2.1 Participants

This study was conducted within the context of Science Start! - Early Reading First, a project funded by the Department of Education designed to enhance the development of language, cognition, and early reading skills of preschool children of low-income, minority, high-risk status using a language-rich science curriculum. The present study took place within a participating Head Start classroom located within a parochial school in an urban setting in the northeastern United States.

An experienced preschool teacher was invited to take part in the study due to her prior interest in concept mapping. The teacher, from this point forward referred to as "Mrs. S.," imparted the information regarding the classroom concept mapping activities to the two paraprofessionals in the room, "Mrs. C." and "Mrs. O." Mrs. S. conducted all large-group instruction in concept mapping, while all three adults participated in small-group mapping activities. A group of 17 4-year-old children assigned to the classroom of the participating teacher, consisting of 8 boys and 9 girls, were part of the targeted activity from which data was collected for the present analysis. The ethnicity of the sample consisted of 11 African-American students, 1 White/Caucasian student, and 2 students classified as "Other." At the time that the targeted concept mapping activity was observed, children ranged in age from 4 years 1 month to 4 years 10 months.

2.2 Procedure

Prior to beginning the study, the researcher met with Mrs. S. to gain access to the classroom and obtain consent. The researcher supplied Mrs. S. with reference literature and detailed information on how the units in the science curriculum could be adapted to incorporate concept mapping activities. Concept mapping was to be employed to teach key concepts already specified in the curriculum. The researcher then provided materials for Mrs. S. to use with her students, including a "mapping board" covered in felt, masking tape for the students to make links between concepts, and several sets of laminated picture word cards, backed with Velcro, consisting of photos of key concepts accompanied by their name.

The researcher visited the classroom and observed four separate "practice" units in which concept mapping took place, each unit consisting of 3-4 large group sessions in which the group built and revised a concept map over the course of one week. The first three units were employed to familiarize the children with materials, teach the children to understand maps as symbols, explain that placement of pictures on the board designated meaningful relationships,

and demonstrate that a set of concepts could be categorized several different ways. The fourth unit, "Pumpkins," served as the targeted unit in which discourse was to be analyzed for the facilitation and presence of metacognitive skills in adults and children. Specific topics in this unit included learning the parts of the pumpkin, learning how pumpkins grow, and learning how people can use pumpkins, for example, to carve a jack o'lantern or to bake pumpkin pie.

Concept mapping activities in the present study were modified in some important ways from activities typically used with older children and adults. Traditionally, concept maps have a hierarchical organization in which more general concepts appear at the top of the map, leading to more specific, less inclusive concepts at the bottom (Novak & Gowin, 1984). However, as the purpose of the activity was to teach new concepts to children whose language is still developing, it was more appropriate to reflect upon the multiple ways in which concepts may be related and understood, rather than focusing on a single relationship. Dynamic relationships can designate ways in which concepts cause, change, and influence each other (Safayeni, Derbentseva & Cañas, 2003), making the content more relevant and meaningful for children than solely statements referring to categorical membership.

Following the success of Figuerido et al. (2004), meaning was designated to different parts of the board; for instance, the right side of the board dealt with "how the pumpkin grows," while the left side of the board concerned "the parts of the pumpkin." Because many of the relationships between concepts were bi-directional (e.g., "the pumpkin has seeds," "seeds are inside the pumpkin"), and the focus was on learning dynamic relationships between concepts, arrows were not used. Instead, maps were typically "read" as text, from left to right and top to bottom. However, some cyclical relationships were also represented (see Figure 1). Cyclic maps capture how a system of concepts works together, providing contextual information indicating a larger process (Safayeni et al., 2003).

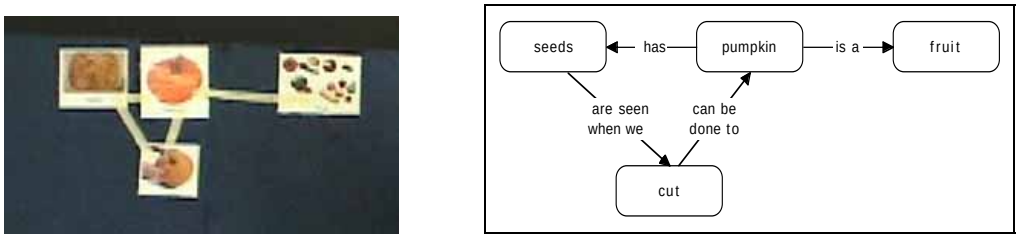

Figure 1. A cyclical relationship between pumpkin, cut, and seeds (constructed in large group).

A second issue concerns the representation of propositions, or the semantic units created by two or more concepts connected by a link that designates their relationship (Novak & Gowin, 1984). In traditional concept maps, propositions are represented by two concept labels connected by a linking word. However, because the children in the present study were pre-readers, the relationship between concepts was verbally stated rather than written. Figure 2 describes a section of a map and corresponding set of propositions that were verbalized in a small group.

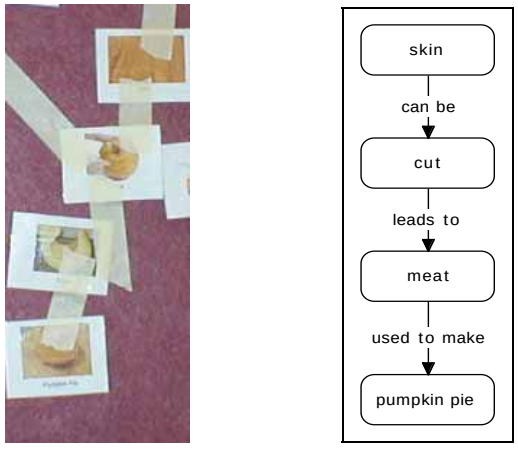

Figure 2. A hierarchical relationship between skin, cut, meat, and pie (constructed in small group).

2.3 Target Activity: Mapping the Pumpkin in Small Groups

On the last day of the "Pumpkins" unit, the class was asked to divide into three small groups, with one adult leading each group in constructing a concept map using the concepts the class had learned over the week. Prior to the target activity, Mrs. S. randomly assigned the children into groups. The target activity took place in small groups, rather than in the large group, in order to allow for a more detailed and thorough analysis of talk and nonverbal behavior in both adults and children. Evidence from prior research using concept mapping activities with young children suggests that small group metacognitive instruction tends to be most effective in promoting student engagement (Georghiades, 2000). Observations in each group were made concurrently using three separate video cameras. The videotapes, which ranged from 20 to 30 minutes in length, were transcribed verbatim. Nonverbal behaviors were also recorded alongside verbal utterances as they occurred in each interaction.

3 Results

The transcript from each group was coded and analyzed separately to explore adult-child talk during the concept mapping task, particularly in the ways that the discourse supported the children's use of metacognitive skills and strategies. Three types of adult supports were coded, including "Facilitates Planning," "Facilitates Monitoring of Progress," and "Creates Opportunities for Student Reflection." Table 1 provides examples from the transcripts illustrating each type of adult support and the activity during which each type of support took place (e.g., selection, placement, or connection of concepts). The excerpts show how teachers provided metacognitive supports prompting children to plan where to place a picture, examine the board for mistakes or missing information, and speculate about conceptual relationships.

	Concept Selection	**Concept Placement**	**Concept Connection**
Facilitates Planning	Which one you gonna do next? Which comes next?	Where do you think that water needs to be? Where we gonna put the skin?	Okay now what's another connector that we wanna do? What do you think it needs to join up with?
Facilitates Monitoring of Progress	Okay, what do we have left? We've got the skin of the pumpkin, the stem, the meat and cutting. Okay, now we're going to work on the inside of the pumpkin.	We didn't leave a spot for the seeds. Nothing's going on up here.	Are we happy with all of our connects? Or do we need to join something else together? We have a problem…the pumpkin patch isn't connected to anything.
Creates Opportunities for Student Reflection	Why should the vine be next? Put your thinking caps on, are we gonna see the meat before we cut it?	Does that make sense over there? Now does everybody agree with that? Why is the fruit next to the vine?	Why should we connect the jack o'lantern to the skin? Do you think you can make a story of why we connected it the way we did?

Table 1. Excerpts of Teacher Utterances Illustrating Metacognitive Skills Through Selection, Placement, and Connection Activities.

A second analysis addressed whether the three adults differed in the kinds of support they provided to the children. For each adult, the total number of utterances during the concept mapping interaction was recorded. The

total number of utterances indicating planning, monitoring, and reflection were also obtained for each adult, allowing a proportion to be calculated describing the frequency that each adult engaged in metacognitive support (Table 2). The proportions reflect that teachers differed in both the types of support provided and in the general tendency to emphasize metacognitive processes. Mrs. S. emphasized the monitoring of progress most frequently, as 20.19% of her utterances reflected monitoring activities. In contrast, Mrs. O. was most likely to emphasize planning, which was observed in 17.75% of her utterances. Mrs. C. demonstrated the lowest proportion of metacognitive supports, regardless of process, compared to the other two adults.

	Mrs. S. (N=431)		**Mrs. O. (N=445)**		**Mrs. C. (N=590)**	
Metacognitive Process	Raw Count	Percent of Total	Raw Count	Percent of Total	Raw Count	Percent of Total
Facilitates Planning	49	11.37	79	17.75	22	3.73
Facilitates Monitoring of Progress	87	20.19	48	10.79	33	5.59
Creates Opportunities for Student Reflection	29	6.73	51	11.46	6	1.02

Table 2. Number and Proportion of Teacher Utterances Facilitating Metacognitive Processes in Each Learning Group

Next, children's verbalizations and nonverbal behavior were analyzed to explore the extent that the participation in the concept mapping task was associated with metacognitive activity. Excerpts from the transcripts, shown in Table 3, reveal that children did engage in metacognitive control as they worked to build the concept map. Children were observed to exhibit planning statements in several ways: in selecting a concept ("how 'bout weighing?"); placement of a concept on the board ("meat right here"); and making a connection between two concepts ("soil to the digging"). Some children noticed problems or gaps in the map ("but they not connected to – this"). Children also made their preferences for choices in concept selection, placement, and connection known by pointing to the board and pictures.

	Concept Selection	**Concept Placement**	**Concept Connection**
Metacognitive Activity – Verbal	How 'bout weighing? We need this	Jack o'lantern here Cut it right here Put it down here Meat right here Cutting right here We need to go right here We can make it right here We need seed right here I would put the pumpkin pie – this	Connect it right there How 'bout this – to this? Seeds to the cutting I wanna connect it here This – to that We gotta get it connected Soil to the digging But they not connected to – this But we didn't get – not this

Table 3. Examples of Student Metacognitive Activity While Concept Mapping

Did children using "metacognitive talk" actually understand the goals of their participation, namely, in understanding their own knowledge and reflecting on ways that concepts are related to one another? According to the transcripts, the extent to which children came to understand the task goals appears to be directly related to the type of adult guidance provided. In many instances, after a child proposed a plan, suggested making a link, or chose to place a concept in a particular area on the board, the adults probed the child's decisions. Adult input often involved asking the children why they made a particular choice, prompting additional discussion about conceptual relationships. In the following example, a thoughtful discussion ensued as the group worked together to decide which concept was to be placed following "seeds" on the concept map:

Mrs. O: And where should the <u>vine</u> go? *(Holds picture of vine up briefly, then puts down.)*

Jason: Right here *(Jason points, then David points to same spot as Jason.)*
Mrs. O: Right where? (looks down at board) The vine should go right – right here? *(Places picture of vine where boys are pointing.)* Okay and why is that? *(Looks up at students.)*
Kelly: Because
Mrs. O: Why should the vine go here next? *(looks to the other end of the table.)* I'm talking to everybody at the table. Why should the vine be next? *(Looks up at students, pulling off a piece of tape.)*
Kelly: Because
Mrs. O: Okay because what Kelly – because what Kelly?
Kelly: Because
Mrs. O: *(raises eyebrows, leans in toward Kelly)*
Kelly: Because the seed is doin' that.

The questioning by Mrs. O. focused the children's attention on the goal that concepts were placed on the board for a reason, requiring children to not only make a decision but think about how it related to the larger goal of the concept map. Through conversation, Mrs. O. drew out Kelly's thoughts on the relationship between the seeds and the vine. In the next example, Mrs. S. clarified a relationship between two concepts that was prompted by a child's input:

Mrs. S: What's our first connect? Between the fruit and what? Between the fruit and…
Lexie: This *(Lexie connects two pictures with her hand)*
Mrs. S: Between the fruit and the seeds because fruit has seeds? *(looks at where Lexie is pointing.)* Good.

At times, if children's suggestions did not make sense, adults encouraged the children to reflect on concept relationships. In the next example, the children were deciding where to place the concept of water on the map. Mrs. S. encouraged the children to consider, before making a decision, about how water is something that is needed for plants to grow.

Mrs. S: Ok Tia, where do you think that water needs to be? *(Hands picture of water to Tia.)*
Daniel: Right here right here *(Daniel points to an empty spot on board in front of him.)*
Mrs. S: Well, we've got the planting stuff going on up here, so what do you think? *(Points to pictures on board.)*
Tia: *(Puts picture of water on board above picture of pumpkin patch.)*
Mrs. S: There, or do you think more up there? By the, where the, all the planting is? *(Points to spot near pictures of "planting stuff.")*
Tia: *(Picks up picture of water, moves picture to the location Mrs. S. suggested.)*
Mrs. S: There's the planting. Okay, what else do we need for the planting?

Students, when given the opportunity, were able to make meaningful decisions about where to place and connect concepts on the map, based on conceptual relationships. Were certain groups of children more or less likely to engage in metacognitive activity while building a concept map? In order to investigate group differences, the number of utterances indicating planning and evaluation were compared to the total number of utterances for each group. Findings suggest that children in Mrs. C's group demonstrated a lower proportion of metacognitive utterances compared to children in the other two groups (Table 5). This finding is consistent with the observation that Mrs. C. provided little metacognitive support to her group of students during the activity.

	Mrs. S.'s group (N=109)		**Mrs. O.'s group (N=151)**		**Mrs. C's group (N=202)**	
Metacognitive Process	Raw Count	Percent of Total	Raw Count	Percent of Total	Raw Count	Percent of Total
Demonstrates Planning	8	7.3	12	7.9	6	3.0
Demonstrates Evaluation	7	6.4	12	7.9	3	1.2

Table 5. Number and Proportion of Student Utterances Indicating Metacognitive Processes in Each Learning Group

Mrs. C. not only provided little metacognitive scaffolding, but also used statements tending to discourage self-directed thinking on the part of the students. Mrs. C. emphasized that children participate by placing and taping

concepts on the map according to her direction, rather than taking responsibility for thinking and decision-making. For example, she used many imperatives, such as “get the pumpkin patch picture” during concept selection, “put it down next to the fruit” during concept placement, and “put that between the soil and the sun” during concept connection. Mrs. C. framed the entire task by stating, “remember, you don’t answer, you don’t get to put the stuff on the board.” When a student’s comment did not make sense, Mrs. C. commented, “you're not, you're not giving me any answers” rather than working to attain a shared meaning. These phrases, focused on outcome rather than process, likely undermined the potential for the concept map to promote children’s reflection and monitoring.

4 Discussion

This investigation has shown that with appropriate adult supports, concept maps are beneficial in facilitating preschoolers’ metacognitive control, including planning, evaluation, and correction. This present study is one of the few studies to examine the benefit of using concept mapping tasks with children of preschool age, and the first to document the ways that preschoolers are able to learn, practice and develop important self-regulatory skills through building a concept map.

This study broadens the ways in which processes involved in construction and monitoring of a concept map are understood. Specifically, examining the extent to which engagement in a concept mapping activity facilitates metacognitive control highlights the ways that socially shared activities are transferred into internal processes within the student (John-Steiner & Mahn, 1996). Concept mapping has sometimes been described in the literature as a “student-directed strategy that does not rely on teacher involvement” (Chularut & DeBacker, p. 260). However, the findings of the present study tend to refute this view, suggesting instead that, in certain circumstances, it is the initial social interaction, through “wrapping language around” the activity, that help learners understand goals and purposes that give the concept mapping task its meaning.

The present findings have important implications for any teacher with a goal of enhancing students’ regulatory thinking skills with the use of concept maps, regardless of the age of the learner. Although concept maps are by their nature tools that promote mindful reflection, students may or may not take full advantage of the benefits of concept mapping, depending on the instructional procedures implemented. The degree that the concept mapping task facilitates self-regulated learning within the student will ultimately depend on the educational climate in which the task is introduced. Ideally, the learner and teacher together will build a shared meaning regarding the value of the concept mapping task in emphasizing thought, reflection, and mastery.

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