Concept Maps: An Alternative Methodology to Assess Young Children

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Abstract

The authors investigated the utility and efficacy of using concepts maps as a research tool to assess young children. Pre- and post- concept maps have been used as an assessment and evaluation tool with teachers and with older students, typically children who can read and write; this article summarizes an investigation into the utility of using this methodology with children in pre-kindergarten and kindergarten. This exploratory study indicated that this methodology is cost-effective, efficient, and developmentally appropriate for use with young children.

Concept Maps: An Alternative Methodology to Assess Young Children

The use of concept maps in early childhood and primary education is not new. Educators have utilized concept maps as instructional and learning tools. Nancy Gallenstein (2003) defines a concept map as a "graphic/visual representation of concepts that shows various relationships between concepts" (p.82). The literature has documented that concept maps can be used to encourage inductive reasoning and critical thinking (Gallenstein, 2003); illustrate relationships among themes (Workman & Anziano, 1994); organize knowledge (Berionni & Baldón, 2006); help children represent what they know and what they are thinking (Birbili, 2006); teach scientific language to kindergarteners (Mancinelli, Gentili, Priori & Valitutti, 2004); and enhance preschooler's knowledge gains

by facilitating metacognitive thinking (Cassata & French, 2006).

The purpose of this manuscript is to introduce concept maps as a methodology in quantitative research with young children as the research participants. While Bannister and Atkinson (1998) used concept mapping as an assessment tool, Birbili (2006) established that teachers can use concept maps as an evaluation tool of pre-existing knowledge and misconceptions. Hough, O'Rode, Terman, and Weissglass (2007) successfully presented a methodology to quantify the differences between a pre- and post- assessment utilizing concept maps. Concept maps are easy to use and provide information regarding whether a treatment, such as a lesson on a subject, participation in a workshop, or an experience, results in the changes of the subject's knowledge about content and/or pedagogy.

Methodology Involving Young Children

Fargas-Malet, McSherry, Larkin and Robinson (2010) examined a variety of methodological and ethical issues that researchers should take into account as they design studies involving young children. The researchers identify the strengths and weaknesses of techniques, methods, and tools when research participants are children. They warn that the methodology used should generate useful and relevant data, and should diminish drawbacks and maximize benefits. These methods include photography, drawings, participatory techniques, use of "stimulus material" or prompts, diaries and other life narrative techniques, observations, and questionnaires. However, all of these methodologies have drawbacks according Fargas-Malet et al. In using photography, they argue that adhering to the original research question is difficult and that confidentiality is sometimes an issue. Analyzing pictorial data is challenging rendering the use of drawings labor intensive. Methodologies that engage

children as active participants are considered best. However, while focus groups and interviews can be beneficial, the resulting data is typically analyzed using qualitative techniques. This limits the research questions that can be fully answered, and the resources needed for interviewing children may be unavailable or costly. Prompts facilitate children's responses in order to gather the information being researched. While they can be effective, they are limited to children who can read and write their responses to the prompt. Narrative techniques such as the creation of books, timelines, or diaries encourage a coherent narrative about what a child is experiencing. Fargas-Malet et al. note, however, that this technique "can be too much like school work" (p. 185), alienating some children and is inappropriate with very young children. Again, data collection using timelines, books, or diaries hinges on the ability for the participant children to be able to read, and convey their thoughts in writing. When observations are used to collect data, researchers need to allot a great deal of time for data collection, coding, and analysis. Questionnaires offer the ability to administer assessments quickly; however young children, especially preschoolers and emerging readers may not be able to communicate in the manner necessary for responses. Through Fargas-Malet et al.'s review of these methodologies, it is clear that a more suitable methodology is needed for children who cannot read or write.

Concept Maps as an Alternative Methodology

Fargas-Malet et al. (2010) suggests that a research methodology must meet the following requirements: "match the research questions of the project, respect limitations of time and resources, be sensitive and ethical, and take into account the particular characteristics and needs of the participants, as well as the cultural and physical setting where

it takes place" (p.181). We propose that concept maps as a data gathering methodology does in fact meet these requirements and also is developmentally appropriate for use with young children.

Concept mapping is a method that can easily be fitted for any research question in which pre- and post- information would be gathered. Concept mapping is extremely efficient in terms of time and resources as the process can take as few as 10 minutes. This method is particularly sensitive to young children and English language learners as they may not be able to express complete sentences, but rather fragments of knowledge known as pre-concepts (Serrano, 2010). These pre-concepts can also be measured by creating a concept map. We propose that concept maps are ethical as they are similar to other assessments used in early childhood such as the KWL (What we KNOW, What we WANT to know, What we LEARNED) charts which are commonly used in classrooms. Lastly, concept maps inherently take into account participants, and cultural and physical settings. For example, concept maps allow the participant to guide the assessment. Once a student has exhausted what they "know" and want to add to the concept map, researchers end the assessment.

How to Create a Concept Map

In order for one to create a concept map, it is necessary to think first of the central idea or root of the concept. This concept should be recorded in the center of the paper. A concept map is hierarchical which will mean that the first level will be closer in relationship to the root idea than the second level, so on and so forth. All levels are related to each other. A concept map highlights the relationship among concepts. Each bubble that is connected to other bubbles is related to each other. If there is no cross-link between bubbles, there is no relationship. Concepts are added to the map once and are not duplicated.

The method of how to create a concept map follows, using the example of "Bully" from the authors' data collection. The first step is to draw a large circle in the middle of the page and write "Bully" inside of it. Next, one would ask the participant(s), "What do we know about bullies?" Sometimes, particularly with younger children, they make give examples such as "Bullies hit us!" The overarching theme of that example is a "Bully is mean" (or hurts other people). An easy way to discover an overarching theme is to ask "If a bully hits someone, what is that an example of?" One version of the answer could be, "It means a bully is hurting people." Now you would have Bully in a circle, a line connected to a first level concept bubble "Bullies hurt people," then another line connected to a second level bubble, "Bullies hit us." Other examples may emerge from the children such as "Bullies call us names." This new bubble would also be on the second level, connected to "Bullies hurt people." If the hierarchical nature of concepts is at first not apparent, add them to the concept map using a temporary method such as a pencil. After the concept map is complete, one can have a conversation about how the concepts are related and if any belong "under" another concept, tightening the hierarchal nature of the concept map.

Figure 1 is an example of a pre-assessment concept map created with information volunteered by kindergarten-aged children who were then exposed to an anti-bullying curriculum. Figure 2 is an example of a post-assessment concept map.

Figure 1

Figure 2

How to Score a Concept Map

Hough, et al. (2007) developed a scoring system based on counting the depth and width of the concept map. The depth and width are then added together to create a Hierarchical Structure Score (HSS). This score represents the complexity of understanding.

Figure 3: Reprinted from Hough, O'Rode, Terman, & Weissglass, (2007)

Root	The main/first concept on a map
Concept	An individual idea or concept on a map depicted by a circle or box
Link	A connecting line between two concepts
Successor of a concept	Any concept that is joined to a previous concept by a link
Depth of Concept Map	**The length of the longest chain on the map**
Level	**Number, *X*, representing the concepts on the map that are *X* links away from the root**
Width	**The number of concepts on the largest level**
Chunk	A group of linked concepts for which the leading concept has at least two successors
Crosslink	A link that connects two separate chunks together to indicate a relationship between them

The higher the HSS, the more complex the understanding of the participant who participated in creating the concept map. One useful way to use the HSS score is to compare pre- and post- concept map scores.

The chart above gives an idea of the complexity that is in a concept map. The pieces of the concept map that will be used to score the concept map are LEVEL, DEPTH, and WIDTH. First, determine the ROOT concept. This is the central concept of which one is soliciting information about, in our example it would be "Bullying." Second, determine the number of LEVELS. Level 1 consists of concepts attached directly to the ROOT. Level 2 consists of concepts attached directly to Level 1, etc. The strand with the greatest number of levels is also the longest concept CHAIN (concepts that are successors of the ROOT, but do not include the ROOT). This number is the DEPTH. Third, the WIDTH is the number of concepts within the largest level. Lastly, in order to determine the HSS score, add the WIDTH and the DEPTH together. As an example of how to score a concept map we will use Figure 1 (Pre-assessment concept map about bullying) and Figure 2 (Post-assessment concept map about bullying.)

In Figure 1 the ROOT is "Bully." There are two levels in this concept map. The first level has the following five concepts in it: "laugh at people," "do mean things," "say mean things," "get in trouble," and "bad news." The second level has the following four concepts in it: "pushing," "hitting," "calling names," and "bad words." Counting the longest chain on a map gives two, or the number of levels. This number is the DEPTH. Next, to determine the WIDTH we look to see which level has the most concepts. Level 1 has five concepts, therefore the WIDTH is five. Lastly, we will determine the Hierarchical Structure Scores (HSS) to obtain an idea of the complexity of the concept map. The HSS equals DEPTH added to WIDTH. Therefore, in this case,

the HSS = 7. In order for the HSS to have statistical meaning, we must have something to compare it to.

In Figure 2, again, the ROOT is "Bully." There are three levels in this concept map. The first level has the following five concepts in it: "say mean things," "get in trouble," "dealing with a bully," "do mean things," and "don't be a bully." The second level has the following 11 concepts in it: "shut up," "calling names," "can't be friends," "teachers or adults help," "get a friend," "hide feelings," "STOP!" "Ignore," "hitting," "pushing," and "laugh at people." The third level has one concept in it: "teacher talks to bully." The length of the longest chain is three, which in this case is the number of levels. This number is the DEPTH. Next, to determine the WIDTH we look to see which level has the most concepts. Level 2 has 11 concepts, therefore the WIDTH is 11. Lastly, we will determine the Hierarchical Structure Scores (HSS) to obtain an idea of the complexity of the concept map. The HSS equals DEPTH added to WIDTH. Therefore, in this case, the HSS = 13.

Using Concept Maps to Evaluate Character Education Curriculum

We provide an example of how concept maps have been used in their research to assess the effectiveness of a character education program with preschoolers and kindergarteners. While the purpose of this paper is not to discuss that research but rather the methodology, Table 1 shows the demographic data for the two school districts in which the data was collected. For further information, the full report is available at http://www.adventureswithtravisandpresley.com. Researchers provided training with the objective of teaching how to utilize concept maps as an assessment tool with young, not yet reading, children. The training included the benefits of using concept maps with non-readers and early

elementary classrooms, how to create concept maps with a class and how to score the concept maps for use in the classroom. We will focus on describing the type of data that were gathered and how it was scored and analyzed

In an effort to protect the human subjects of interest, in this case Pre-Kindergarten- and Kindergarten-aged children, the researchers ensured anonymity by having participating teachers collect data via concept maps. Because the purpose of the data collection was to determine effectiveness of a character education curriculum, the teachers were instructed to collect pre- and post- data from small groups (4-6) of children. To properly assess pre- and post- maps, children were kept in the same groups for both data collection activities. Data submitted by the teacher volunteers addressed five of eight character education topics: How to Deal with a Bully (4 teachers), Good Teamwork (2 teachers), Good Table Manners (1 teacher), Be Polite (1 teacher), and Share and Take Turns (1 teacher). These data represented 113 to 137 Prekindergarten and Kindergarten children (depending on the sizes of the groups). This methodology can be utilized by developing concept maps with individuals, small groups, or large groups depending on the research questions, type of data desired, and limitations of time and resources.

To exemplify how this methodology can be used, we will briefly describe our study using concept maps. The teachers in our study were instructed to implement the character education curriculum. Participating teachers were asked to create concept maps with the topic of the curriculum as the root concept. In the examples we present, "BULLY" as the root concept. Teachers worked with small groups of 4-6 children, creating pre-assessment

Table 1
Population Profile by Race According to the 2010 Census

Race	Percentage of the Population in the City A	Percentage of the Population in the City B
White persons, percent, 2010	81.6%	79.5%
Black persons, percent, 2010	3.6%	4.7%
American Indian and Alaska Native persons, percent, 2010	2.3%	3.9%
Asian persons, percent, 2010	1.1%	5.6%
Native Hawaiian and Other Pacific Islander, percent, 2010	2.2%	0.1%
Persons reporting two or more races, percent, 2010	3.8%	5.0%
Persons of Hispanic or Latino origin, percent, 2010	10.3%	4.3%
White persons not Hispanic, percent, 2010	77.7%	77.0%

http://quickfacts.census.gov/qfd/states/40/4023950.html

concept maps of the children's knowledge in each small group before introducing the curriculum. As specified in the character education curriculum materials a month later, post-assessment concept maps were developed. It was stressed that the children in the small groups had to be the same in the pre- and post- assessments, to ensure a fair comparison. We suggest that teachers and/or caregivers be thoughtful in the composition of the group so that no one child dominates or falls quiet. This thoughtfulness can also include the administrator, ensuring that each child contributes to the concept map.

The concept maps were collected and coded by the researchers. The maps were scored quantitatively using the measures outlined in Figure 2, developed by Hough, O'Rode, Terman, and Weissglass (2007). It is recommended that the researcher establish inter-rater reliability of the scores before analysis. This can be done by having two coders for one fourth of the maps. We would like to stress that these scores are relative to what and who is being assessed. There are no absolute "high" scores, only scores that are higher or lower in relation to previous scores or other groups' concept maps.

Changes in the concept map score totals, as well as the changes in the pre- and post- Hierarchical Structure Scores (HSS) are then statistically analyzed. We suggest dependent t-tests to examine total number of concepts and HSS scores. For example, our results indicated a significant increase in groups of children's knowledge [t (41) = -7.85, p < .05] from before the curriculum implementation (M = 6.90, SD = 3.24) to after the curriculum implementation (M = 11.48, SD = 3.09). Results for HSS scores indicated a significant increase in groups of children's knowledge about the character education curriculum concepts they were taught [t(41) = -7.05, p < .05] from before exposure to the

curriculum (M = 7.19, SD = 2.83) to after exposure to the curriculum (M = 9.88, SD = 2.72). In other words, groups of children had more complexity in their concept maps at the end of the curriculum exposure than before it. In this case, complexity means the students were able to generate more words and phrases for their post-assessment map than their pre-assessment map. From this data, we infer that this complexity was a direct result of the curriculum.

Implications of Concept Map Methodology

The purpose of this manuscript was to explore the use of concept maps as a methodology in quantitative research. Many methodologies employed by researchers have strengths and weaknesses, and research involving young children is particularly difficult. Concept maps may overcome the limitations of current methodologies. Researchers have used them as an assessment tool (Bannister & Atkinson, 1998) and as an evaluation tool of pre-existing knowledge and misconceptions (Birbili, 2006). Concept maps have also been used by teachers as a tool to organize thinking and depict relationships of concepts. They have also been used to compare pre- and post- assessment data with adult participants (Hough, et. al, 2007).

We propose that this methodology can be used with very young children, even those who may struggle with concepts and/or sophisticated language skills. This methodology is cost-effective, labor-effective, and developmentally appropriate for use with young children. Finally, this methodology is a unique approach that allows for the combination of qualitative and quantitative analysis.

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