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Metacognitive Manifestations during Engineering Tasks among Preschool Children from Different Cultural Background and its Relation to Mathematical Problem Solving

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Abstract

This study has two objectives. The first goal is to examine the relationships between the following three variables: metacognitive thinking ability, engineering ability, and problem-solving skills in early childhood, where metacognition and engineering construction are measured during gameplay of LEGO models. The second goal is to examine if there are differences between preschoolers from different populations in these measures.

Metacognitive ability includes complex knowledge about thought and cognitive processes, and the methods of establishing these very processes. Some call this 'thinking about thinking.' Metacognitive knowledge in learning relates to three components: knowledge about the learning task, knowledge of thought processes in general, and knowledge about oneself as a person learning and thinking. Metacognition has different roles in promoting higher order thinking processes, as it supervises, regulates, and controls thought processes.

In the past, most researchers believed that metacognition is a sophisticated system that requires interaction between multiple factors and components and develops only at the age of 8-10 years old. But recent research shows that children do in fact have metacognitive abilities from an early age. In these studies, age-appropriate research methods were used to measure metacognitive abilities in early childhood. In this study, using video documentation and analysis (on line), children's metacognitive and engineering abilities were assessed.

The study included children of preschool age (N = 91) enrolled in regular education and were not at risk of learning disabilities according to reports from their parents and teachers. The study participants were sampled from two countries, Israel (N = 56) and England (N = 35). The study population from Israel included ultra-Orthodox (N = 20) and secular (N = 36) children. Initially, background data on the children's cognition was collected using Raven and PPVT. Data on the metacognitive abilities and engineering capacities were obtained from the entire sample during game activity of model construction of LEGO. Additional data was also collected from the Israeli children to assess their ability to solve problems in mathematics.

The study was conducted in three stages. In the first stage, verbal and nonverbal cognitive abilities of the participants was assessed. In the second stage, the basic mathematical skills and the ability to solve problems in mathematics were assessed. In the final stage, the metacognitive and engineering abilities were assessed during game activity of building models of LEGO according

to a picture. The entire construction process was documented on video, and the optimal model was then selected and analyzed from a metacognitive and engineering perspective.

The results of the study indicate a strong positive correlation between metacognitive abilities and engineering ability as well as ability to solve mathematical problems. There is also a strong positive correlation between the ability to solve mathematical problems and the ability to construct complex models at a high level of difficulty. There was no correlation between the ability to solve mathematical problems with the level of accuracy and the quality of model construction. Spatial perception was also found to have a significant positive correlation with the ability to solve problems in mathematics and to construct complex models.

In assessing differences between different populations, we first examined whether there were differences in the basic cognitive ability. There were no differences between Israeli and English-born children in the intelligence tests, but there were significant differences in the various components of metacognition. Israeli children showed more evidence of command and control, whereas English children, showed evidence for the ability to regulate and work independently. There was also differences in engineering capacity. Children from Israel built more complex models however Children from England built models in a more qualitative manner and were more careful about accuracy and suitability for models.

Differences in basic cognitive abilities of the Israeli participants (but not the English participants) were examined. Since significant differences were found in the general intelligence tests, we used MANCOVA to control for this variable. In examining the differences between the groups in the dependent variables, several differences were found in favor of children from the ultra-Orthodox sector: in the metacognitive ability (planning, control, and supervision) and in the ability to solve problems in mathematics. In addition, significant differences were found in the complexity of the models that the respective participants built. Children that received ultra-Orthodox education built more complex models, although not necessarily of better quality.

The findings of this study extend the knowledge about the ability of young children to use metacognitive skills and the relationship between metacognition and engineering construction as well as problem solving in mathematics. This has implications not only in theoretical terms but also in practical terms. The uniqueness of this study stems from the fact that the relationship between the three variables in this study has hardly been studied in the past, and certainly not been studied at the early childhood age. This study opens a window in understanding the important role

of metacognitive skills in early childhood during play activity as it pertains to both to the engineering ability of the child, and his mathematical ability. In addition, in recent years, emphasis has been placed on introducing mathematical and engineering education in early childhood. The findings of this study indicate positive correlations between the ability to solve problems in mathematics, spatial thinking and Engineering construction ability. These findings influence the early childhood curriculum. Since, these areas are interrelated but not parallel it is important to cultivate these abilities among kindergarten children as a qualitative basis for continuing their studies in schools and in general.