The Influence of Meta-Cognitive Intervention on Children Age 5-10 Tendency to Spontaneous Recognition of Mathematical Structures

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Abstract

Students tend to describe their everyday surroundings by focusing on different aspects of the environment, including on figure and numeric features. Their perception of the environment is often related to their personal goals and the way they interact with the environment. They can use different ways to focus on different characteristics in their environment, such as verbal description or non-verbal performance. Can students focus spontaneously on mathematical structures such as random order, multiplication pattern and arithmetic series, the tendency to ROMS (Recognition of Mathematical Structures)? Does this tendency change with age? Is it related to mathematical achievements? And can it be developed? These questions underlie in this study.

The aim of the present study is: (1) to examine the tendency to ROMS, i.e. spontaneous focus on random order, multiplication pattern and mathematical series, in verbal tests and non-verbal performance tests (imitation and drawing); (2) to examine the relationship between ROMS tendency and cognitive abilities: executive functions (attention and working memory), logical skills (non-verbal IQ) and verbal skills (description, conceptualization and abstraction); (3) to examine the correlation between the ROMS tendency and achievement in mathematical knowledge and mathematical reasoning; (4) to Develop a meta-cognitive intervention program to improve ROMS tendency and in addition examine its impact on ROMS tendency and mathematics achievement.

The present study was conducted as a comparative cross-sectional study. The 296 participants were students from three age groups: kindergarten (N=94), second grade (N= 105) and fourth grade (N=97). The study was comprised of two parts, pre-intervention and post-intervention. The study hypotheses were examined using assessments of cognitive abilities, mathematical achievements, tasks developed for investigating the tendency to ROMS, and a meta-cognitive intervention that guided students to a collaborative meta-cognitive mathematical discourse during their in-formal activity.

The findings indicated that the study hypotheses were largely confirmed. The tendency to ROMS was observed as developing with age. As such, fourth graders exhibited a higher tendency to ROMS compared to kindergarteners and second graders. Similarly, second-graders exhibited a higher tendency to ROMS compared to kindergarteners in the three ROMS tests, verbal and non-verbal imitations and drawing. When examining the differences between the tests, a more complex image emerges. While the tendency to nonverbal ROMS (imitations) was

found to be higher than the tendency to verbal ROMS, the tendency to verbal ROMS was found to be equal to the tendency to nonverbal ROMS (painting) among kindergarteners and second graders. Among fourth graders, the tendency to nonverbal ROMS (painting) was higher than the tendency to verbal ROMS. The hypothesis regarding the relationship between the tendency to ROMS and mathematical achievements, (e.g) mathematical knowledge and mathematical reasoning, was partially confirmed. While a strong correlation was found between the tendency to ROMS and mathematical reasoning, a weak correlation was found between the tendency to ROMS and mathematical knowledge in all three age groups. The hypothesis that the tendency to ROMS would mediate cognitive abilities and mathematical achievements, was partially confirmed. no single model was found explaining the relationships between the study variables and mathematical achievements. Three models were found, one for each age group. explaining the relationships between ROMS tendency, cognitive abilities and mathematical reasoning. The hypothesis that meta-cognitive intervention would contribute to the tendency to ROMS and to mathematical achievements compared to the control group in the three age groups, where a conversation on the activity was held (without metacognitive guidance), was confirmed.

The findings of the present study have theoretical and practical implications. In theoretical terms, the study provides a multidimensional explanation of the tendency to ROMS, which consists of two combined dimensions, ranging on a sequence of complexity. One is on the verbal-performance axis and the other is on the mathematical structure axis, concluding random order multiplication pattern and arithmetical series. The combination of the two levels of complexity was key to examining the development of the tendency to ROMS from the ages of five to ten and to understanding the tendency to ROMS as a differential mediator between cognitive ability and mathematical reasoning in the three age groups. In practical terms, the combination of the three dimensions of the intervention program had an impact on the students' achievement regarding their tendency to ROMS, mathematical knowledge and mathematical reasoning. The first dimension was meta-cognitive guidance questions presented to students through the "mind map"; the second dimension was a collaborative discourse that developed following the meta-cognitive questions; the third dimension was in-formal activity as educational content in formal mathematics studies.

The uniqueness of the current study is exhibited in both theoretical and practical aspects. In the theoretical aspect, the uniqueness lies in the development of tools to examine the tendency to ROMS, in examining the development of the tendency to ROMS between the ages

5 – 10 and in examining among the different age groups, the relationship between the tendency to ROMS and cognitive abilities, executive functions (attention and memory processes); logical skills (non-verbal IQ); verbal skills (description, conceptualization and abstraction).

In the theoretical aspect, the uniqueness of this study is in the combination between collaborative' meta-cognitive and mathematical meta-discourse and the students' in-formal activity as educational content during formal mathematical studies at school. The findings of the study can support the body of knowledge in the field of cognition and mathematics as well as to contribute to understanding the benefit of integrating personal interests and contents of the students' in-formal activities into formal learning processes at school. As a result, the activities initiated by the students in their immediate environment could provide for mathematical and cognitive learning opportunities. This learning process should begin with making room for the students' personal interests and goals in in-formal activity they initiate, followed by an intervention of support and guidance which, on one hand, aims to mathematically analyze the activity and on the other, maintains a sense of autonomy in controlling and engaging the students in the learning process. A combination of planned and comprehensive formal learning that leans on collaborative learning as well as on the students' informal knowledge, has proven to advance the students' achievement in mathematics. Seeing as informal mathematical knowledge serves as the basis for success in formal mathematics studies, it is important to understand it and to identify its components.

The findings of the study suggest that the tendency to ROMS is a measurement tool that points to other aspects of mathematical education among the various age groups that participated in the current study. It is also possible to note the contribution of a meta-cognitive intervention program at school, to developing mathematical thinking among the students and to promote meaningful mathematics learning.