

Investigating the relation of counting capability, visual attention, hearing perception, and meta-cognitive knowledge with mathematical competence in preschool children in the city of Isfahan

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Abstract

The purpose of the current research was to investigate the relation of cognitive precedent variables (counting capability, visualizing, hearing perception and meta-cognitive knowledge) with mathematical competence in preschool children in city of Isfahan. Statistical population of the study was 199 children (ages between 5 and 6 years) who were randomly selected. Research instruments were Utrecht Mathematical Competency, Counting Capability Test, Visualizing Attention Test, Meta-cognitive Abilities Test, and Reading Comprehension Test. Findings indicate that counting

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capability %49, meta-cognitive knowledge %46, visualizing attention %41, and hearing perception %38 predict mathematical competence in children. It is suggested that preschool coaches reinforce mentioned skills in children.

Key Word: mathematical competence, counting capability, visualizing, hearing perception, meta-cognitive knowledge, pre-school children

Introduction

Mathematical functionality includes a set of components, the most important of which are numbers knowledge, numerical facts, mathematical concepts perception, and the ability to follow-up with methods (Doeker, 1998). The development of mathematical concepts among children is shaped even before school teachings (Rosenick, 1989; Oreizy, 2004; Mousavi, 2003). Children reach special fundamental concepts from the beginning such as absolute measure (big or small), the relationship of a part with the whole, and reasoning pre-sample schemes (Anola, Leskin, & Normi, 2004). These skills and abilities become the mathematical development foundation for children (Ginzberg, 1997; Rosenick, 1986, 1989). Also, there has been emphasis on information organization and the control of mental processes through shaping of schemes from children's side. It should be mentioned that this emphasis is in many of the psychological theories related to children's mathematical education (Alamol-hodayi, 1980). Cognitive variables are basic for further mathematical function development, including the ability to count objects (Jolman & Gysteel, 1978), meta-cognitive knowledge (Butterfildo Frerti, 1987), and visualizing attention (Anola, et. al, 2004). In the field of ability to count objects (Olson & Ros, 1991; Giri et. al., 2000; and Hourd, 2001), the results have shown that children with inabilities related to math have serious problems in counting. This matter is independent from the I.Q. level and the abilities to read. The following two reasons are mentioned for this matter: The first is

that the ability to count is an important basic variable for further mathematical skills, which helps the children to use the information related to the mathematic knowledge automatically and to focus their attention more on complex issues and more difficult methods (Gersten & Chard, 1999; Rosenick, 1989). The second reason, which Sigler (1986) and Giri, Braun, & Samaranik (1991), and Lemeer & Seeger (1995) have mentioned is that counting ability is a background policy for gaining mathematics knowledge which not only helps the individual in automation of taking advantage from mathematics-related information, but is also partially responsible for the level of information-retrieval exactness.

Another cognitive variable which has role in mathematical functioning is attention deficit (Badian, 1983). For example, researches showed that difficulty in attention, has reverse relationship with mathematic skill (McLain & Hich, 1997; Badian, 1983). Also, Akreman & Anhal & Dickman (2001) have stated that children with attention deficit disorder face difficulty on the first school-days in automating the use of numerical facts and there is delay in their automation. The beginning and leading of attention processing on different tasks needs different resources which impacts it. This includes the tasks and responsibilities that are well understood and the representation of information which should be kept in mind that becomes possible through attention. Therefore by attention deficit they become deeply weak (Rouyer, et. al., 1999).

Mathematic tasks include visual and hearing signs which impact the mathematical function through perception of instructions as well as understanding concepts through hearing. Therefore concept understanding through the hearing of instructions can be another important element in mathematical functioning (Jordon et. al., 2003).

The other basic cognitive variable related to mathematical competency is the meta-cognitive knowledge which is related to children's knowledge and related perception of the cognitive processes (Falavel, 1976). For example, Lockangeli, Kouy, and Bosco (1977) realized in their research on grade five students, that children with lesser meta-cognitive knowledge are less effective

compared to students with higher meta-cognitive knowledge. Similar findings have been concluded in other researches (DoSote, Royrzo-Bayski, 2001 and Borkosky, 1992). Two reasons were mentioned for meta-cognitive knowledge effect in mathematical competency: The first is that meta-cognition helps the learners to adjust better with various responsibilities as well as backgrounds and different demands for the problem solving, and hence are able to succeed (Boukartes, 1999; Desoute et. al., 2001). Also meta-cognitive knowledge helps the learner to present all of his/her cognitive abilities, abilities that are highly related to educational advancement (Alexander et. al., 1995; Alar Kan, Napic & Freys, 2000). Swanson (1990) found out that students with higher meta-cognitive knowledge have higher functionality in solving mathematical problems compared to other students because they are able to process the data in a more effective way. The researches by Avanian (1998) and Samadi (2004) have also pointed to the important role of meta-cognitive education on concept-understanding, learning-speed, and mathematical problem solving. The purpose of this research is to investigate the relationship between basic cognitive variables (counting ability, visualizing ability, hearing perception, and meta-cognitive knowledge) and mathematical competency in pre-school children.

Research Method

Considering the research identity and goals, the co-relation method has been used. In this research, the base variable is mathematical competency and the predicting variables are 'the counting ability', 'visualization attention', 'hearing perception', and 'meta-cognitive knowledge'.

The Cases

The research statistical population include forty-five thousand, 5 to 6 year old children of pre-school and kindergarten centers in the city of Isfahan in 2005-2006 school year, from which 199 children were randomly selected.

Research Tools

1. **The UTRECHT Scale for Children's Mathematical Competence:** This scale which was built by Korporal (1995) and Endrijt (1996) (Narrated by Oreizi, Kavosian, & Kadivar, 2004), consists of 8 sub-scales (comparison, categorization, one to one correspondence, seriation, orderly counting, structural counting, estimated counting, general perception). This scale has been normalized in Iran by Oreizi, Kavousian, and Kadivar (2004) and the reliability coefficient of the entire scale has been reported to be 0.91 using the Cronbach Alpha method.

2. **Tools for Counting Abilities:** Children's counting ability has been assessed with the help of the mathematical recognition test by Salonen et. al. (1994), which includes the following sub-scales:

○ **Forward counting:** In this level the child is asked to count forward from a number that is announced to him/her. For example it is asked from him/her to count from a number such as 3, 8, and 12 to 20. If the child is able to successfully complete the task, a score of one is put aside for him/her; otherwise a score of zero is considered for him/her.

○ **Backward counting:** In this level the child is asked to count backward from a number that is announced to him/her. The base numbers are 4, 8, 12, and 19. Therefore for the number 4, the child is to state the numbers 3, 2, and 1. If a child is able to successfully complete the task, a score of one is put aside for him/her; otherwise a score of zero is considered for him/her.

○ **Counting numbers forward without order:** In this level, the child should count similar to when he counts forward, without stating the numbers. For example he is asked to give the number we reach when moving 5 unites forward from 3. Answering this question correctly results in a score of one. The sum of all testable scores results in the produced counting scale in the sub-test.

3. Visualization Attention Test:

Visualization attention takes place by attention assessment in the collection of tests developed by Napsi, Korkman, Kirk, and Camp (1998, 2000) which are tools for designing the neuro-cognitive development in the pre-school and primary school periods. It is conducted on children of age 3 to 12. The visualization attention sub-test is one of the sub-tests in this Napsi collection. Its purpose is the evaluation of children's ability for keeping visualization attention. In this level, the child is asked to quickly select twenty images (target elements) from among a hundred images. The test includes three images (cat, flower, tree). The children's responsibility is identifying and marking the images in which there is a specific image (such as cat). The sample for visualization experience is collected through the subtraction of the total number of incorrect answers with correct numbers; hence the child's maximum score is 20. After this, the score is divided to the sum of the time taken to complete the task. The time range limit is three minutes, after which the test is stopped automatically.

4. Meta-cognitive Abilities Test: Meta-cognitive ability test is from the series of meta-cognition and mathematic identification tests by Salonen et. al., (1944), which includes four similar tasks, in each of which, the child faces two or three cards. On each of these cards, there is a boy or a girl drawn who is busy with a task. In this level, the child should point to the card that shows the most effective type of learning in process.

One of the tasks is to give three girls each a card with an image in an unorganized way. They are asked to tell a story with the cards. One of them puts the cards in a circle. The other orders them in a line along each other and then looks at the images to realize what orientation is best for a story. The third child first puts all images on the table, arranges them, and finally looks at them. The children must decide which of their responsibilities they do better. When the children have explained their reason for selecting the cards, the tester writes their notes. The scoring in this meta-cognitive test is in two ways. First, two independent scores are considered for each of the four tasks. The first score is based on image-selection, which is

between one and three variables (1=The least effective method for learning, 3=The most effective method for learning). The second score is based on the children's oral explanations, which should be done by a content-analysis tester. Therefore the above two scores are combined by weight, in which the most weight holding is by content-analysis.

For example children who have incorrectly selected the image but have provided a suitable explanation for them, gain a higher score compared to children who have selected the right image but provided the wrong explanation. The reason for this weight-based combination is that meta-cognitive knowledge is related to cognitive processes (Falavel, 1976 narrated by Mohseni, 2004).

5- Reading perception content: To assess the reading content perception, Korpilati's test for reading content perception, (1988) is used. In this level, the children see three images and are at the same time exposed to a sentence. At this stage they are asked to select the image that is more related to the sentence. There are ten images in this task and one mark is earned by each right answer.

Research findings

Table 1 – Reliability tests based on Cronbach's Alpha method, split-half coefficient, and test-retest coefficient.

| Scale reliability | Cronbach's alpha | | Test-retest reliability | | Split-half reliability coefficient |
|-------------------------|------------------|------------------|-------------------------|------------------|------------------------------------|
| | Main research | Present research | Main research | Present research | |
| Mathematics' Competency | 89/0 | 91/0 | 92/0 | 93/0 | 90/0 |
| Counting ability | 79/0 | 77/0 | 94/0 | 81/0 | 75/0 |
| Visual | 77/0 | 71/0 | 92/0 | 84/0 | 73/0 |

| | | | | | |
|--------------------------|-------------|-------------|-------------|-------------|-------------|
| attention | | | | | |
| Listening comprehension | 74/0 | 71/0 | 77/0 | 72/0 | 72/0 |
| Meta-cognitive knowledge | 80/0 | 76/0 | 72/0 | 74/0 | 73/0 |

Table 2 shows the mean and the standard deviation of the research tools on the cases separated to boys and girls.

Table 2– The mean and the standard deviation of the research tools separated to boys and girls

| Scale's measure | Boys =103 | | Girls= 104 | |
|--------------------------|--------------|--------------|--------------|--------------|
| | Mean | St. D. | Mean | St. D/ |
| Utrecht test | 15/36 | 14/12 | 28/41 | 39/12 |
| Counting ability | 64/6 | 24/1 | 22/5 | 36/1 |
| Visual attention | 22/0 | 12/0 | 37/0 | 14/0 |
| Listening comprehension | 73/5 | 42/1 | 21/8 | 39/1 |
| Meta-cognitive knowledge | 27/10 | 19/1 | 28/12 | 37/1 |

In table 3, the co-relation coefficients between the research tools is provided. This table shows that the basic variables of counting ability, visualization ability, meta-cognitive knowledge, and hearing ability have significant relationship with mathematical competency.

Table 3 – The relationship between basic cognitive variables and mathematical competency

| Scale | Utrecht Test | Counting ability | Hearing ability | Meta-cognitive knowledge | Hearing content perception |
|----------------------------|--------------|------------------|-----------------|--------------------------|----------------------------|
| Utrecht Test | 1 | | | | |
| Counting ability | 0.76 *** | | | | |
| Visualization attention | 0.51 *** | 0.42 ** | | | |
| Hearing content perception | 0.46 *** | 0.42 ** | 0.49 *** | | |
| Gender (girl) | -0.11 | -0.09 | -0.31 *** | -0.22 ** | 0.21 ** |
| Gender (boy) | -0.14 | -0.013 | -0.36 *** | -0.32 ** | 0.39 ** |

= ***P < 0.01

** = P < 0.01

In table 4, the multi-fold regression variables for predicting mathematical competency are provided from the variables of hearing attention, counting ability, meta-cognitive abilities, as well as content perception. The information in the above table, showing the 'counting ability', 'visualization ability', 'meta-cognitive ability' and 'hearing perception' predict the mathematical competency.

Table 4- Regression variables predicting mathematical competency

| | Amounts | β | t | R^2 |
|--------------------------|---------|---------|-------|-------|
| Variables | | | | |
| Counting ability | | 3.26 | 2.76 | 0.19 |
| Visualization ability | | 0.08 | -2.01 | 0.02 |
| Hearing perception | | 3.47 | 2.94 | 0.14 |
| Meta-cognitive knowledge | | 4.22 | 3.16 | 0.21 |

** = $P < 0.01$

Discussion and Conclusion

Most of the conducted researches about cognitive variables effective on mathematical functioning, have selected variables as the predicting variables that are strictly for mathematical purposes. Some such variables include recalling the numerical facts from semantic memory (Giri, 1993), and numerical reasonings (Yazdouchi & Oreizi, 2004). In this research a range of cognitive processes have been investigated. Although these cognitive processes play a role in mathematical functioning, they are not strictly the variables of the mathematical fields. Kill & Hall (1995) stressed on the introduction of variables that play part in children's mathematical development but are not limited to mathematics. The effective cognitive variables on children's mathematical functioning, which have been investigated in this research, meaning, hearing perception, visualization resources, and meta-cognitive knowledge, plus the specific mathematical variables, which is ability to count, have a significant relationship with children's mathematical competence. Based on the statement by the survey (1993) regarding the sources of attention, mathematical problem solving is related to schemes and heuristics (explorative

processes). A person who possesses a low level of attention and concentration is unsuccessful to correctly solve the problem due to the existing problem in mentally activating the correct schemes.

Also, attention sources, such as visual attention, have impact on the method of direction of cognitive processes in solving a problem (Badian, 1983). Due to this reason, Oreizi (2002) found significant relationship between visualization and mathematical functioning in Felangan's industrial tests. Perhaps, the relationship between two variables is caused due to both variables having the role of visualization in them.

Regarding meta-cognition role in mathematical competence, Anurita & Varas have mentioned that meta-cognition is the reflection and the sign of coordination of students' ability with various homework problem-solving. Therefore it can be considered as a foundation for students' mathematical competence. Swanson (1990) indicated that students who have higher meta-cognitive skills possess better mathematical functions compared to other students. As well, Avanian (1993) has pointed to the role of meta-cognitive policies in students' perception and speed of learning. The result of researches by Anola, Lesikinen, Lorkanen, and Normi (2004) regarding the hearing perception and its impact on mathematical performance has shown that hearing perception is in relation with mathematical performance in pre-school children. The result of the research by Jordan et. al. (2002) had previously shown that the use of vocal information through hearing perception is in relation with performance in vocal issues in Algebra. This is while hearing perception has a role from the beginning and even from before the beginning of school in shaping the students' mathematical competence.

The cognitive variable of "ability to count" is also related to mathematical competence. The current research, also, has shown that counting ability has a role at least in mathematical competency development and its flourishing. Olson Wery (1991), Giri et. al. (1995), Giri (1999), Oreizi & Abedi (2004) have shown that students with the ability to learn mathematics face challenges in solving problems that require counting abilities. Its main reason is

that the ability to count makes possible the automation of numerical calculations (Rosenick, 1989). As well, Giri and others (2001) emphasize the automation of the counting abilities while believing that these are through acquisition. They believe that the automation makes it possible for the children to achieve more and more complex mathematical functions, just like a driver whose changing of the gear or holding down the gas or break pedal has become automatic so that he can control the car using more complex activities. If these activities have not become internalized for him, it is obvious that a part of his mind is busy with it and therefore will be less successful in controlling the automobile (Gersten & Chard, 1999). According to the current research results, the stress is on non-specialized mathematic variables including the visualization attention, hearing perception, and meta-cognitive knowledge. Therefore it is necessary that a portion of the primary-school period goals are focused on the development of these cognitive variables so that the students' foundational mathematics competency is strengthened. Now the question is whether the mentioned variables are shaped once and for ever in the students, or whether they increase as the children pass through childhood in a cumulative and mass-mode format. By studying these variables longitudinally (with consecutive assessments on the students in successive years) it is possible to investigate their development aspects. The previous studies by Oreizi, Kavosian, and Kadivar (2004) had not provided an answer for that particular case of cognitive styles due to the certainty of the studies in the field of relationship between the cognitive processes and mathematical competence. It is suggested to use mathematical models in future studies (for example through Latent Growth Curve Model with consecutive assessments longitudinally in order to study the relationship between cognitive processes and mathematical competence) in that particular cognitive style. Also in the studies by Zahra Gouya (2000) and Ma'soume Samadi (2004) it has been stressed to show the need for new and considerable theories such as the meta-cognitive theories besides the current cognitive theories. They have also pointed out that to succeed, it is necessary to be equipped with cognitive and

meta-cognitive policies when solving mathematical problems in addition to the acquisition of principles of mathematical concepts.

Specialists in this field such as Seyf (2003) and Kadivar (1995 & 2001) have pointed out the importance of teaching meta-cognitive policies in the teaching-learning process and therefore it is suggested that these topics be placed in the teacher-training and teachers' on-the-job-training, especially teachers in the pre-school level.

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