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Spatial Abilities as a Predictor to Success in the Kangaroo Contest

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Abstract: In the few years since the Kangaroo Contest arrived in Israel, we have discovered that all the winners in grades 2-6 succeeded in spatial abilities (SA)-oriented tasks. In this study, we investigate a potential relationship between spatial abilities and mathematical performance (focusing on non-standard problems) in mathematically-motivated students (MMS) who participated in the Kangaroo Contest. We also sought to ascertain whether the correlation between scores of SA tasks and the rest [of the] non-standard problems (RNSP) in the contest is age-dependent. A strong correlation between SA tasks and mathematical performance, together with well-known malleable spatial abilities can lead us to the conclusion that the development of spatial abilities in early childhood is necessary as a predictor of later mathematics achievement. This issue is important for students at all levels and especially for MMS, some of whom will later become mathematically promising students.

Key words: spatial ability, mathematics performance, competitions, student motivation

1. Introduction

In research literature, evidence can be found with regard to the correlation between spatial ability and mathematical performance. People who perform better on spatial tasks have been shown to perform better on tests of mathematical ability (Delgado & Prieto, 2004; Lubinski & Benbow, 1992; McLean & Hitch, 1999). This correlation holds true at different ages (Gathercole & Pickering, 2000; Kyttälä, Aunio, Lehto, Van Luit, & Hautamaki, 2003), whereas greater spatial ability at age thirteen is associated with a preference for mathematics-related subjects at age eighteen and helps predict success in STEM (Science, Technology, Engineering, and Mathematics) careers (Wai, Lubinski, & Benbow, 2009). Spatial ability at age 18 moderately correlates with raw SAT (Scholastic Assessment Test) mathematics scores, and remains a significant predictor of mathematical ability after controlling for general intelligence, processing speed and working memory (Rohde & Thompson, 2007). Some researchers even assume that spatial processes are recruited for mathematics (Presmeg, 2006; Rasmussen & Bisanz, 2005).

The study we describe in this paper has begun to identify the relation between spatial ability and mathematics performance focused on solving non-standard problems in mathematically motivated students (grades 2-6) who participated in the Kangaroo Contest in Israel.

2. Spatial Abilities

There are many definitions of spatial ability; it is generally thought to be related to skills involving the retrieval, retention and transformation of visual information in a spatial context (Velez, Silver & Tremaie, 2005) and includes the ability to manipulate the information represented in visual or graphical forms (Diezmann & Watters, 2000). Halpern (1986) explains that spatial ability is the ability to imagine what an irregular figure would look like if it was rotated in space. She adds that it is the ability to

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discern the relationship between shapes and objects.

In this paper, we utilize the following criteria, which are considered the most practical method of dividing spatial abilities into components (Höffler, 2010):

Spatial orientation: The ability to perceive the positions of various objects in space, relative to each other and relative to the viewer, particularly across changes in orientation.

Mental rotation: Mental manipulation/rotation of remembered objects or elements in a scene.

Spatial visualization: Ability to perceive complex spatial patterns and comprehend imaginary movements in space.

3. Mathematics Competitions as a Motivating Factor

Mathematics competitions, in their recent form, have more than one hundred years of history and tradition. Kahane (1999) claimed that large popular competitions could reveal hidden aptitudes and talents and stimulate large numbers of children and young adults.

Robertson's study (2007) of the history and benefits of mathematical competitions reported that success in math competitions, and in math achievement in general, seemed to be linked to the love and interest instilled in students and an appreciation for math and problem solving methods. It also provides an opportunity to acquire high-level skills with extra training and the development of a particular culture that encourage hard work, learning, and achievement. Bicknell (2008) also found numerous benefits to be gained from the use of competitions in a mathematics program, such as student satisfaction, the enhancement of students' self-directed learning skills, their sense of autonomy and co-operative team skills.

The interplay between cognitive, metacognitive, affective, and social factors merits particular attention by researchers because it may give us more insight into the development of mathematical potential in young learners (Applebaum, et al., 2013).

Mathematical competitions are organized in different formats, at different places and for different types of students. The Kangaroo Contest model offers many students an opportunity to be exposed to challenging mathematics activities that go beyond the regular classroom. As such, it may help them to apply their skills to new situations and, at the same time, enrich their learning experience (Kenderov et al., 2009). We assume that mathematical competitions, even ones that do not target the mathematically gifted, would attract such students; therefore, when examining their abilities, we could better understand their nature and how to foster their development in different cognitive domains. In this study, we investigate the possible relationship between mathematics performance and spatial abilities in the context of Kangaroo tasks.

4. Kangaroo Contest

Each year, over 6.5 million pupils aged 5-18, from over 70 countries around the world, participate in the Kangaroo Contest.

The contest is composed of just one standardized test: no selection, no preliminary round, and no final round. It takes place in March, on the same day and at the same hour in all countries, and consists of 24-30 multiple-choice questions of increasing difficulty. For each question, a choice of five answers (distractors) is provided.

The Kangaroo Contest is more of a game than an uncompromising competition (Dolinar, 2012). The most obvious difference is that the Kangaroo Contest is not just for the most mathematically talented students. Instead, it aims to attract as many students as possible, with the purpose of showing them that mathematics can be interesting, beneficial and even fun. Although, sadly, it has generally become accepted that the vast majority of people find mathematics difficult, very abstract and unapproachable, the number of contestants in the Mathematical Kangaroo proves that this need not be the case. With a huge number of competitors, the Kangaroo Contest helps eradicate such prejudice towards mathematics.

Choosing appropriately challenging tasks is an important condition in the successful contribution of mathematical competitions to developing students' learning potential (Bicknell, 2008). In the case of the Kangaroo Contest, the problems are selected each year from a long list of problems provided by the organizers from all the participating countries (over 70). In contrast to other competitions, the Kangaroo Contest problems are more appropriate, according to the challenging task concept suggested by Leikin (2009). Such tasks should be neither too easy nor too difficult, so as to motivate students and develop their mathematical curiosity and interest in the subject.

5. The Structure of the Kangaroo Contest

The test consists of 24 multiple-choice problems for grades 2-4 (and 30 multiple-choice problems for grades 5-6). All the problems are sub-divided into three groups, each consisting of 8 problems (10 problems for grades 5-6) and rated according to level of difficulty. Problems 1-8 (1-10 for grades 5-6) are defined as Easy level; problems 9-16 (11-20 for grades 5-6) are defined as Average level; and problems 17-24 (21-30 for grades 5-6) are defined as High level. Participants in the Kangaroo Contest have 75 minutes to solve the problems. Using any accessories other than pens and paper is forbidden.

Each of the 24 problems (30 for grades 5-6) contains five items: four distractors and only one correct answer. The students are tested in different venues all over the country and their tests are sent for evaluation to the country's contest organizers. Almost all the tasks in the Kangaroo Contest are different, in both style and type, from the tasks students encounter in their textbooks.

5.1 The Research Questions

In this study, we investigate the following research questions:

(1) What is the relationship between spatial abilities and mathematical performance (focusing on non-standard problems) in mathematically motivated students (MMS) who participated in the Kangaroo Contest?

(2) Does the correlation between the scores of the SA tasks and the rest [of the] non-standard problems in the contest depend on the participants' age?

(3) Does spatial ability depend on participants' age?

(4) In what kinds of problems (e.g. SA tasks, Number Sense, Common Sense, and Word Problems) is the gap in the mean scores of the different ages meaningful?

5.2 Participants

In this study 268 2nd-grade students, 471 3rd-grade students, 245 4th-grade students, 263 5th-grade students and 197 6th-grade students participated in the Kangaroo Contest in Israel (2014). The students' ages ranged between 7 and 12 years old, and they came from all over the country, from both large cities and small villages, and from different socio-economic backgrounds.

5.3 Tools

As described above, each student took a 75-minute test prepared by the Kangaroo International Committee. Note that 3rd and 4th grade students took the same test and, likewise, 5th grade students took the same test as 6th grade students.

In each test, a different number of problems focused on spatial abilities:

2nd grade: there were 13 SA problems from a total of 24 problems;

3rd and 4th grade: there were 5 SA problems from 24 problems;

5th and 6th grade: there were 5 SA problems from 30 problems.

According to our research, all the problems were divided into two categories: (1) SA problems – such tasks that demanded spatial abilities and (2) rest [of the] non-standard problems (RNSP) – based on the following topics: common sense (logic), number sense and word problems.

In this research, each correct answer earned the students one point, while no points were awarded for no answer.

5.4 Data Collection and Analysis

In the first stage, we collected data based on the performance of the top-ranked solvers of the SA tasks. We discovered that in all the grades, the winners (i.e.1st place) had absolute scores on the SA tasks. In Table 1 presented below, the data illustrate the performance of the students awarded the top three places in the Contest (per grade) for solving SA tasks only.

In the Kangaroo Contest, the 2nd grade winner solved all 13 SA tasks. Likewise, the second placed student achieved the same result. Only two of the 268 students solved all 13 SA tasks in the test, with the student in third place solving 12 of the 13 SA tasks.

In the Kangaroo Contest for the 3rd grade, the winner solved all 5 SA tasks. The students that took second and third places in the Contest solved 4 out of 5 SA tasks. There were 9 out of 471 students in the 3rd grade who solved all 5 SA tasks in the test.

For the 4th grade, the top 3 contestants solved all 5 SA tasks, with a further 27 out of 471 students in the 4th grade solving all 5 SA tasks in the test.

It should be noted that the percentage of 4th grade students (over 10%) who solved all 5 SA tasks on the test was more than five times greater than the percentage of 3rd grade students (2%).

In the Kangaroo Contest for 5th graders, the winner solved all 5 SA tasks. The second and third placed students solved 4 and 3 of the 5 SA tasks, respectively, with 5 of the 263 students in the 5th grade solving all 5 SA tasks on the test.

For the 6th grade, the winner and the runner-up both solved all 5 SA tasks, with the third placed student solving 4 of the 5 SA tasks on the test.

In both the 5th and 6th grades there was the same percentage of students that solved all 5 SA tasks: which was about 2%.

Looking for inverse correlation we checked the ranking of students that solved all SA tasks.

In the Kangaroo Contest for 2nd graders, apart from the students who took the first two places, no other students solved all 13 of the SA tasks. Six other students who solved 12 out of the 13 SA problems achieved 2nd to 8th ranks overall.

In the 3rd grade there were a further eight students that solved all 5 SA problems; however, they were more widely scattered in the Contest: ranging from 14th to 158th place.

Likewise, in the 4th grade, 24 more students solved all 5 SA problems, and they also had a wider distribution in the Contest: ranging from 8th place to177th place.

In the 5th grade there were only four more students who solved all 5 SA problems, they attained between 4th and 41st place.

In the 6th grade there were only two more students that solved all 5 SA problems and they took the 27th and 37th place.

At the next stage, for each grade, we found the mean and the standard deviation for both the SA and RNSP tasks in the test. Subsequently, the Pearson correlations between the scores of SA tasks and the RNSP in the test were ascertained for each grade.

All collected data are presented in Table 2.

Table 1 The winners' performance on the SA tasks only.

	The number of SA tasks solved by winners, by grade				
Students' Place in the Contest	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
1st	13 of 13	5 of 5	5 of 5	5 of 5	5 of 5
2nd	13 of 13	4 of 5	5 of 5	4 of 5	5 of 5
3rd	12 of 13	4 of 5	5 of 5	3 of 5	4 of 5
The number of students that solved all SA tasks	2 of 268	9 of 471	27 of 267	5 of 263	4 of 197

Table 2 Comparing scores in SA tasks vs RNSP in the Kangaroo Contest

Grade	Number of students	Number of SA tasks	Mean (St Dev)		Pearson Correlation between SA tasks and the RNSP
			SA	RNSP	
2	268	13 of 24	0.4446 (0.1788)	0.4054 (0.1670)	0.552**
3	471	5 of 24	0.4017 (0.2416)	0.3730 (0.1680)	0.436**
4	245	5 of 24	0.5649 (0.2629)	0.5334 (0.1970)	0.551**
5	263	5 of 30	0.3510 (0.2230)	0.3608 (0.1519)	0.435**
6	197	5 of 30	0.4213 (0.2123)	0.4319 (0.1541)	0.441**

$^{**}P \leq .005$

6. 2nd Grade Data

In the 2nd grade, 13 of the 24 tasks focused on spatial abilities. The large number of SA tasks in the test can be explained by the statement that students at this age still have difficulty in reading and understanding textual problems; this is mainly due to the limited arsenal of mathematics tools available. The means for the two groups of tasks (SA and RNSP) for the 2nd grade were close: $\bar{x}_{SA}(2^{nd}\ \ grade) = 0.4446,\ \ s = 0.1788$ and $\bar{x}_{RNSP}(2^{nd}\ \ grade) = 0.4054,\ \ s = 0.1670$. We found a strong correlation between these scores: $r = 0.552$ and $p \leq 0.005$.

7. 3rd and 4th Grades Data

There were five common SA tasks in the Kangaroo tests for the 3rd and 4th grades. The means of the two groups of tasks (SA and RNSP) for the 3rd grade were also close: $\bar{x}_{SA}(3^{rd}\ grade) = 0.4017,\ \ s = 0.2416$ and $\bar{x}_{RNSP}(3^{rd}\ \ grade) = 0.3730,\ \ s = 0.1680$. We found a strong correlation between these scores: $r = 0.436$ and $p \leq 0.005$.

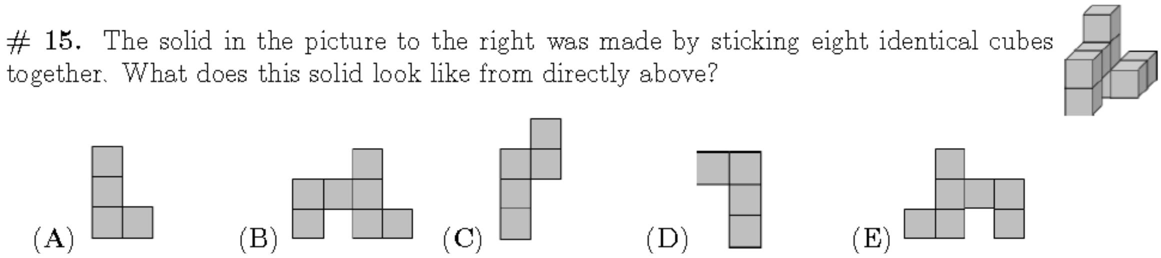
The means of the two groups of tasks (SA and RNSP) for the 4th grade were also close: $\bar{x}_{SA}(4^{th}\ \ grade) = 0.5649,\ \ s = 0.2629$ and $\bar{x}_{RNSP}(4^{th}\ \ grade) = 0.5334,\ \ s = 0.1970$. We found a strong correlation between these scores: $r = 0.551$ and $p \leq 0.005$.

The scores for the same set of problems in different grades were significantly different. The mean of the set of SA problems for the 4th grade was $\bar{x}_{SA}(4^{th}\ \ grade) = 0.5649$ which was 40% more than the mean of the same set for the 3rd grade: $\bar{x}_{SA}(3^{rd}\ \ grade) = 0.4017$.

An independent-samples t-test was conducted to compare 3rd grade students' scores in solving SA tasks with those of 4th grade students. There was a significant difference in the scores for 3rd grade students ($\bar{x}_{SA}(3^{rd}\ grade) = 0.4017,\ \ s = 0.2416$) and 4th grade students ($\bar{x}_{SA}(4^{th}\ \ grade) = 0.5649,\ \ s = 0.2629$); $t(714) = -8.35,\ \ p < 0.0001$. These results suggest that students' age does have an effect on scores in SA tasks. Specifically, our results suggest that when students' age increases, their score in solving SA tasks increases as well.

After performing a detailed analysis of the differences between the 3rd and 4th grade scores of the SA tasks, we discovered that in all five SA tasks, the 4th grade students performed better than their 3rd grade, counterparts, with the largest gap found in task #15 (regarding Mental Rotation).

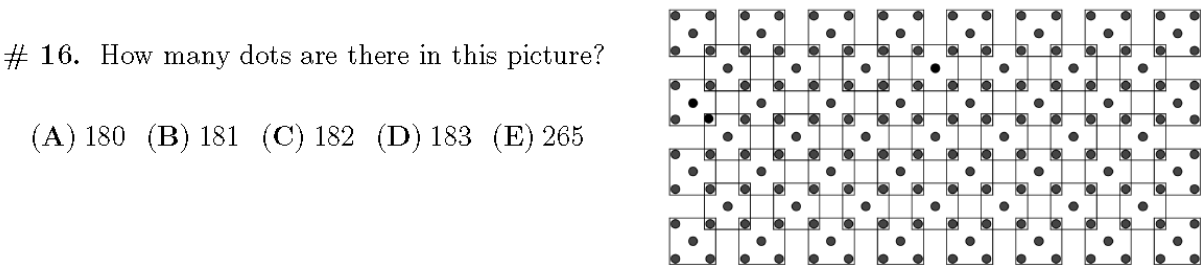
The mean for 3rd grade students of task # 15 was: $\bar{x}_{N=471}(3rd\ \ grade) = 0.1975$ whereas the mean for 4th grade students on the same task was approximately 70% greater: $\bar{x}_{N=245}(4th\ \ grade) = 0.3347$. The distribution of chosen distractors per grade presented in Table 3.



Pic. 1 Task 15 suggested for 3rd and 4th grades students in the 2014 Kangaroo Contest

Table 3 The distribution of answers in Task #15 for 3rd and 4th grades.

Distractor	A	B	C (correct answer)	D	E	No answer
3rd grade (N=471)	2.3%	53.9%	19.7%	1.5%	15.1%	7.4%
4th grade (N=245)	1.6%	47.8%	33.5%	1.6%	12.3%	2.4%



Pic. 2 Task 16 presented to 3rd and 4th grades students in the 2014 Kangaroo Contest.

Table 4 The distribution of answers in task #16 for 3rd and 4th grades.

Distractor	A	B (correct answer)	C	D	E	No answer
3rd grade (N=471)	19.5%	13.4%	5.5%	11.0%	40.9%	9.6%
4th grade (N=245)	18.1%	26.9%	10.6%	9.8%	26.9%	6.9%

We can see that in both grades, distractor B attracted the attention of about half of the students in both grades. An explanation for this might be that students looked at the shape from the right side rather than viewing it from above as the question required.

Another SA problem which generated a large deviation in the means of 3rd and 4th grades was task #16 in the test (see above), on the topic of "Common Sense".

The mean of 3rd grade students on this task (# 16) was: $\bar{x}_{N=471}(3\text{rd} \quad grade) = 0.1338$ whereas the mean for 4th grade students on the same task was more than 100% greater: $\bar{x}_{N=245}(4\text{th} \quad grade) = 0.2694$. The distribution of chosen distractors per grade was presented in Table 4.

We can see that distractor E attracted the attention of ~41% and ~27% of 3rd and 4th grade students respectively. Obviously, when the students counted the number of "five point" blocks  they obtained 53 units. Therefore, 53 times 5 equals 265; however, they did not consider the intersections of these "five point" blocks and failed to subtract 84 common points that had been counted twice. Choosing an alternative answer could be explained by the students' confusion in directly counting all the points in the diagram.

In total, we found that in the 15 (of 24) tasks, there was a significant difference in favor of 4th grade students compared to 3rd grade students. The distribution of these tasks was as follows: Number sense – 3 tasks (out of 5), Common Sense – 6 tasks (out of 9), Textual problems – 3 tasks (out of 5), SA – 3 tasks (out of 5). We therefore claim that in each mathematical topic there was approximately the same significant gap for each of the tasks.

It should be noted that there was not a single task (out of 24) in the Kangaroo Contest in which the mean of the 3rd grade students was equal or greater than the mean of the 4th grade students.

8. 5th and 6th Grades Data

There were five common SA tasks in the Kangaroo test for the 5th and 6th grades. The means for the two groups of tasks (SA and RNSP) for the 5th grade were close: $\bar{x}_{SA}(5^{th}\ \ grade) = 0.3510,\ \ s = 0.2230$ and $\bar{x}_{RNSP}(5^{th}\ \ grade) = 0.3608,\ \ s = 0.1519$. We found a strong correlation between these scores: $r = 0.435$ and $p \le 0.005$.

The means of two groups of tasks (SA and RNSP) for the 6th grade were also close: $\bar{x}_{SA}(6^{th}\ \ grade) = 0.4213,\ \ s = 0.2123$ and $\bar{x}_{RNSP}(6^{th}\ \ grade) = 0.4319,\ \ s = 0.1541$. We found a strong correlation between these scores: $r = 0.441$ and $p \le 0.005$.

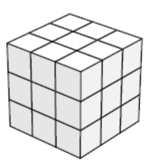
The scores for the same set of problems in different grades varied significantly. The mean of the set of SA problems for the 6th grade was $\bar{x}_{SA}(6^{th}\ \ grade) = 0.4213$ which was 20% more than the mean of the same set for the 5th grade: $\bar{x}_{SA}(5^{th}\ \ grade) = 0.3460$.

An independent-samples t-test was conducted to compare 5th grade students' scores in solving SA tasks with those of 6th grade students. There was a significant difference in the scores for 5th grade students ($\bar{x}_{SA}(5^{th}\ \ grade) = 0.3510,\ \ s = 0.2230$) and 6th grade students ($\bar{x}_{SA}(6^{th}\ \ grade) = 0.4213,\ \ s = 0.2123$); $t(458) = -3.65,\ \ p < 0.0005$. These results suggest that students' age does have an effect on scores in SA tasks. Specifically, our results suggest that when students' age increases, their score in solving SA tasks increases as well.

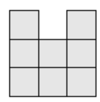
We also discovered that in all five SA tasks, the 6th grade students had better results than the 5th grade students and the largest gap was in question #21 (related to Spatial Orientation).

The mean of 6th grade students for this task (# 21): $\bar{x}_{N=197}(6^{th}\ \ grade) = 0.2030$ was approximately 30% greater than the mean $\bar{x}_{N=263}(5^{th}\ \ grade) = 0.1558$ achieved by 5th grade students on the same task. The distribution of chosen distractors per grade was presented in Table 5.

We identified that other than SA problems that generated large differences in the means of the 5th and 6th grades, task # 26 in the test (see below) on the topic of "Common Sense", combined with the word problem, further increased the deviation.



 # 21. The $3 \times 3 \times 3$ cube in the picture is made of 27 small cubes. How many small cubes do you have to take away to see the picture on the right as the result when looking from the right, from above, and from the front?



(A) 4 **(B)** 5 **(C)** 6 **(D)** 7 **(E)** 9

Pic. 3 Task presented to 5th and 6th grades students in the 2014 Kangaroo Contest.

Table 5 The distribution of answers in task #21 for 5th and 6th grades

Distractor	A	B	C	D (correct answer)	E	No answer
5th grade (N=263)	20.5%	17.9%	17.1%	15.6%	17.9%	11.0%
6th grade (N=197)	13.7%	15.2%	19.8%	20.3%	18.8%	12.2%

\# **26.** The king and his messengers are travelling from the castle to the summer palace at a speed of 5 km/hr. Every hour, the king sends a messenger back to the castle, who travels at a speed of 10 km/hr. What is the time interval between any two consecutive messengers arriving at the castle?

(**A**) 30 min (**B**) 60 min (**C**) 75 min (**D**) 90 min (**E**) 120 min

Table 6 The distribution of answers in Task #26 for 5th and 6th grades.

Distractor	A	B	C	D (correct answer)	E	No answer
5th grade (N=263)	25.1%	30.0%	4.9%	10.6%	11.4%	17.9%
6th grade (N=197)	23.9%	18.8%	3.0%	21.3%	11.2%	21.8%

The mean of 5th grade students on this task (# 26) was: $\bar{x}_{N=263}(5^{th} \quad grade) = 0.1065$ whereas the mean for 6th grade students on the same task was twice the amount: $\bar{x}_{N=197}(6^{th} \quad grade) = 0.2131$. The distribution of chosen distractors per grade was as presented in Table 6.

Choosing distracter A (30 min), which attracted the attention of about one-quarter of the students in both grades, could be explained by the following incorrect argument: "the messenger can pass through a distance of 5 km in half an hour".

Choosing distractor B (60 min), which also attracted the attention of about one-third of the students in the 5th grade and about one-fifth of the students in the 6th grade, could be explained by the next consideration: "the king sends the messenger every hour."

In addition to the two problems presented above (SA – 1 and Common Sense – 1) there were four more problems in the test with significant mean gaps in favor of 6th grade students: Number Sense – 2 tasks (out of 7), Geometry – 1 task (out of 2) and Textual problem – 1 (out of 7). We cannot point to any one topic that was more difficult for the 5th grade students than it was for 6th grade students.

We found that in all grades there was a strong correlation between SA tasks and the RNSP in the test. The differences between the means of SA and RNSP in each grade were not significant. Interestingly, in grades 2-4 the means for SA problems were greater than the respective means of RNSP, whereas in grades 5-6 we found the opposite phenomenon. It should be noted that the differences were not significant. We also found a positive correlation between the participants' age and their score on the SA tasks.

9. Conclusion

In this study, we examined the correlation between solving SA tasks and RNSP in the Kangaroo Contest for grades 2-6. We found a strong correlation between scores obtained by participants in the Kangaroo Contest when faced with SA tasks vs RNSP in the same test: in the 2nd grade: r =0.552, in the 3rd grade: r =0.436 in the 4th grade: r =0.551, in the 5th grade: r =0.435 and in the 6th grade: r =0.441 ($p \leq .005$ in all grades).

Answering the second research question we cannot point to any connection between the age of the students and the correlation between the students' performance in SA and RNSP.

Previous research has established a link between spatial ability and mathematics learning, in which it was found that both children and adults who possess better spatial abilities also have higher math scores (Delgado & Prieto, 2004; Lubinski & Benbow, 1992; Robinson et al., 1996).

Many studies indicate that spatial thinking and mathematics are related, especially in early grades, thus indicating that early intervention is crucial for closing achievement gaps in math (Duncan et al., 2007; Jordan, Kaplan, Ramineni, & Locuniak, 2009; Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Starkey, Klein, & Wakeley, 2004).

Cheng & Mix (2014) showed that appropriate development of spatial thinking can improve mathematics learning in children aged 6 to 8 years. The meta-analysis conducted by Uttal et al. (2013a, b) showed that the development of spatial thinking leads to an average improvement of almost 1/2 of a standard deviation in spatial ability measures. Considering all the aforementioned data, there is an excellent basis to assume that training in spatial thinking would improve math performance.

Answering the third research question, we can claim that the age of the participants in this study was indeed a factor which influences success in solving SA problems.

If in the 3rd grade, the mean of students in solving SA tasks was $\bar{x} = 0.4017, (s = 0.2416)$; in the 4th grade (who dealt with the same problems), the mean was significantly greater: $\bar{x} = 0.5649, (s = 0.2629)$.

If in the 5th grade the mean of students in solving SA tasks was $\bar{x} = 0.3510, (s = 0.2230)$; in the 6th grade (who dealt with the same problems), the mean was significantly greater: $\bar{x} = 0.4213, (s = 0.2123)$.

This finding supports the research of Mix & Cheng (2012) claiming that the relationship between spatial ability and mathematics performance varies with age.

Answering the fourth research question, we can say that in all mathematical domains (i.e. SA tasks, Number Sense, Common Sense, and Word Problems) there were significant differences of students' performance according to their age.

An observed correlation between students' performance in solving SA tasks and the rest [of the] non-standard problems in the Kangaroo Contest supports the importance of developing spatial ability in mathematical learning of mathematically motivated students, who later are like to become mathematically promising students.

In contrast to other studies, the present research examined (1) the correlation between scores of SA problems and scores of non-standard problems and (2) a research population consisting of mathematically-motivated students.

Extending research to samples of different ages, employing longitudinal designs and focusing on gender issues will lead to a better understanding of the dynamic nature of mathematical – spatial relationships.

Future research may find it valuable to examine whether some of the components of SA, i.e. *Spatial orientation, Spatial visualization* or *Mental rotation*, influence one or more of the other topics of RNSP: *common sense, number sense* and *word problems*.

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