**gender issues in the Virtual Training to Kangaroo Contest**

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*In today’s technologically enhanced world mathematics competitions become available to more boys and girls who are interested in challenging tasks. The issue of attracting girls to mathematics in general and to math competitions in particular has captured our attention when we were analyzing data from the final stage of the Kangaroo mathematics contest in Israel. With general finding showing boys having better results, further analysis of differences across Grades 2-6 indicates that in some grades the gap is smaller than in others. For instance, only insignificant differences were found in Grade 4 for all difficulty levels. Furthermore, on some tasks, across all five grades, the girls' performance was better than the boys'. In this respect, continuous investigation is needed to ascertain whether a certain trend exists and if so, what might be the possible factors that make it happen.*

*In this paper we look at gender-related issues pertinent to participation in the Virtual Training to Israeli Kangaroo Contest in 5th and 6th grades. Our study concentrates on the following questions: Are there any difference in boys' and girls' participation patterns and their performance in online problem-solving program as a part of training to the annually Kangaroo Contest.*

*Key words: gender, online mathematics competitions, challenge, problem-solving*

**Introduction**

Many educators express concern regarding the gender gap in mathematics performance and the underrepresentation of women in science, technology, engineering and mathematics (STEM) careers (Hyde et al., 2008). Gender inequity is particularly evident in data related to the number of girls that participated in the International Math Olympiad, or the number of female professors in university mathematics and engineering departments (Hyde & Mertz, 2009).

Several researchers pointed at mathematics performance in favor of boys (Aunola et al., 2004, Githua & Mwangi, 2003, Marsh et al., 2008), whereas others (Lindberg et al., 2010) claimed that no significant gender gap exists in mathematics. Moreover, Robinson and Lubenski (2011), and Brown and Kanyongo (2010) showed that over the last four decades, girls have achieved slightly better grades in mathematics than boys.

As Halpern et al. (2007) pointed out, “There are no single or simple answers to the complex question about sex difference in mathematics”, and all “early experience, biological factors, educational policy, and cultural context” need to be considered when approaching this question. Gherasim et al. (2013) also argued that there is a need for more studies on gender differences in order to fill the gaps regarding the mechanisms that are conducive to enhancing mathematical performance.

In what way do gender differences appear (if at all) in the context of mathematics competition? Indeed, Niederle and Vesterlund (2010) found that gender difference in competitive performance does not reflect the differences in non-competitive performance. Gneezy et al. (2003) even revealed that gender gap in performance under competition conditions is three times greater than in non-competitive environments. Leedy et al. (2003) studied beliefs held by students participating in regional math competitions, as well as those held by their parents and teachers. They found that mathematics is still viewed as a male-dominated discipline, while girls and women fail to acknowledge the existence of the bias. They argue that the task of the school is not to ignore or deny differences in learning styles, attitudes and performance but to acknowledge and use them for developing strategies aimed at providing gender-equitable education. However, there is not enough data about how gender-related differences are manifested in mathematics competitions and what patterns emerge from these differences.

Applebaum et al., (2013) investigated gender issues in the context of the Virtual Mathematical Marathon by studying participation and performance. While observing students’ participation during the first two years of the competition, they found that girls and boys showed similar patterns regarding the decision to remain in the competition, or to abandon it, regardless of the results in previous rounds.

In this research we analyse boys' and girls' performance in the first stage of 2018 Israeli competition (as part of an International Kangaroo Contest), whereas students participated in online internet training throughout 16 weeks (students had to identify themselves) from home or sometimes from their schools.

**mathematical Competitions: opportunities for learning and fun**

Mathematical competitions in their current form boast more than 100 years of history and tradition, are organized in different formats, in different venues and for different types of students. They are considered to be “one of the main tools to foster Mathematical Creativity in the school system“ (Silva, 2014). Kahane (1999) claimed that large popular competitions could reveal hidden aptitudes and talents and stimulate large numbers of children and young adults. Bicknell (2008) found the use of competitions in mathematics programs to have numerous advantages, such as student satisfaction, enhancement of students’ self-directed learning skills, sense of autonomy, and cooperative team skills. Robertson (2007) reported that success in mathematics competitions, and mathematics achievements in general, seem to be linked to the love and interest instilled in students’ learning experience. It also provides an opportunity to acquire high-level skills with extra training and the development of a particular culture that encourages hard work, learning, and achievement. 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).

Among the variety of competitions, the Kangaroo Contest stands out in its main objective: popularization of mathematics with the special purpose of showing young participants that mathematics can be interesting, beneficial and even fun (Kenderov et al., 2009).

Kangaroo Contest’s target population is not just 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 Contest proves that this need not be the case. With a huge number of competitors, the 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 contrast to other more challenging 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.

 Regarding the tasks and learning opportunities, Brinkmann (2009) mentioned that, when asked about the most beautiful mathematical problems, Grade 7 and 8 students named puzzles, while commenting that the problems should not be too difficult. For example, more than half of the students cited as 'a beautiful math problem' one of the 2003 Kangaroo Contest problems, which targeted spatial abilities in the context of paper folding (Brinkmann, 2009). Moreover, Applebaum’s recent study confirmed earlier research that spatial thinking and mathematics are interrelated, especially in early grades, thus indicating that early intervention is crucial for closing achievement gaps in math (Applebaum, 2017).

**gender-related data on mathematics competitions: is there an issue?**

Several educators express a concern regarding gender difference in mathematics performance and underrepresentation of women in science, technology, engineering and mathematics (STEM) careers (National Academy of Science, Beyond Bias and Barriers: Finding the potential of women in academic science and engineering, 2006; Hyde et al., 2008). Gender inequity is particularly evident in data related to number of girls participated in the International Math Olympiad, or number of female professors in university mathematics and engineering departments (Hyde & Mertz, 2009). There are several ways in how this problem may be addressed.

First, psychologists are looking for gender differences in brain structure, in hormones, in the use of brain hemispheres, nuances of cognitive or behavioural development and consequent spatial and numerical abilities that may predispose males to a greater aptitude and success in mathematics (Halpern, 1997, Moir & Jessel, 1989). However, several finding reported in the literature regarding this matter are not consistent (Spelke, 2005), partly due to the fact that experience alters brain structures and functioning (Halpern, et al., 2007).

Second, detailed measurements of students’ achievements in mathematics are being performed by educators at different stages of schooling in an attempt to identify the moment of occurrence and further dynamics of gender gaps in mathematics. Many studies are consistent in their observation that the gender gap becomes more evident as students progress towards higher grades, especially if testing involves advanced topics in mathematics and higher cognitive level items. In contrast to earlier findings, some more current data provide no evidence of a gender difference favouring males emerging in the high school years (Hyde et al., 2008).

Yet another interesting observation is that “achievement gains are insufficient unless the self-beliefs of girls have changes correspondingly” (Lloyd, Walsh, & Yailagh, 2005, p.385). Research that views gender differences through the lenses of the attribution theory (see e.g. Bandura, 1997) suggests that girls tend to attribute their math successes to external factors and to effort and their failures to their own lack of ability (self-defeating pattern), whereas boys tend to attribute the causes of their successes to internal factors and their failure to external factors (self-enhancing pattern). Since it is better for an individual to attribute success to ability, rather than to effort because ability attributions are more strongly related to motivation and skill development (Schunk & Gunn, 1986), these patterns have explained in part girl’s poorer achievement (Lloyd et al., 2005).

 According to Asante (2012) secondary students' attitudes towards mathematics are influenced by set of factors as “School environment, teachers' attitudes and beliefs, teaching styles and behaviour and parental attitudes towards mathematics”. Focused on girls being discouraged from studying math this study strongly argue that girls receive less encouragement and support in the classroom than boys. Williams, (2006) showed that many classrooms created the atmosphere of competition among students. Such an atmosphere played to the strength of boys, who were socialized to compete, but often intimidated girls, who were more often socialized to collaborate.

 Third way of addressing the gender gap in mathematics is to investigate the influence of socio-cultural factors. According to Von Glaserfeld (1989), the context in which learners find themselves is important in the acquisition of knowledge. First, it was found that parents have greater expectations for sons regarding their mathematical performance that they have for daughters, and this has an influence on the students’ results (Leder, 1993). It was also observed that even talented and motivated girls “are not immune to the ill effects of gender bias” (Leedy, LaLonde, & Runk, 2003, p.290). In this respect it is unfortunate that stereotypes that girls and women lack mathematical ability persist and are widely held by parents and teachers (Hyde et al., 2008). Leedy et al. (2003) studied beliefs held by students participating in regional math competitions, as well as by their parents and teachers, and found that mathematics is still viewed as a male domain by men, while girls and women fail to acknowledge the existence of the bias. Yet other researchers have found interesting results that showed that gender differences in mathematics performance are declining, or non-existent in gender equal countries (Quest et al., 2010, Guiso et al., 2008). Leedy et al. (2003) also argue that the task of the school is not to ignore or deny differences in learning styles, attitudes and performance but to acknowledge them and use for developing strategies aiming at providing gender equitable education.

In conclusion, in all three perspectives in research on gender in mathematics – cognitive, instructional, and socio-cultural – care is needed in considering how the data are collected, examined and interpreted because within neither approach there is a fully consistent theory that could explain the existing gender difference observed at the higher level of mathematical tasks. As Halpern et al. (2007) point out, “there are no single or simple answers to the complex question about sex difference in mathematics”, and all “early experience, biological factors, educational policy, and cultural context” need to be considered when approaching this question.

**technology and gender: what patterns** EMERGE **in mathematics competitions?**

While previous section summarizes research related to gender issue in mathematics education showing no conclusive findings, similar observation can be drawn from technology-related studies that we will review very briefly. For instance Fogasz (2006) reports that when talking about classroom practices that involve computers as a learning tool, mathematics teacher held gendered beliefs about their students that incorporation of technology has more positive effects on males' classroom engagement and on their affective responses, and thus technological approach benefits boys' learning to a greater extend.

At the same time Wood, Viskic, & Petocz (2003) found no gender differences in the students’ use of computers or in their attitudes towards the use of computers. This agrees with ideas expressed by Willams (2006) quoted above, who reviews studies showing that girls are as confident and active as are boys in creating webpages, writing blogs, reading websites, and chatting online, among other activities.

As was mentioned in publications Freiman et al., (2009); Freiman & Applebaim, (2009), Internet can be a suitable challenging environment for organizing mathematics competitions and problem solving activities, contributing potentially to the development of mathematical ability and giftedness. A recent analysis of middle-school students participating in a web-based mathematics competition Carreira et al. (2012) argue that although it cannot be said that by solving problems online, students do better in mathematics, their data provide us with an evidence that the use of technology tends to involve more complex mathematical thinking.

Being a part of a powerful set of out-of-regular-classroom activities such as mathematical clubs, mathematical camps, mathematics competitions (Olympiads), on-line mathematics competitions play a significant role in nurturing interest and motivating young learners of mathematics, as well as in identification and fostering the most able and talented (Skvortsov, 1978; Karnes & Riley, 1996; Robertson, 2007; Bicknell, 2008). The choice of appropriate challenging tasks is also an important condition of success of mathematic as competitions in developing students' learning potential. The tasks should motivate students to persevere with task completion and develop mathematical curiosity and interest in the subject. As well, they must support and advance students' beliefs about the creative nature of mathematics, the constructive nature of the learning process, and the dynamic nature of mathematical problems as having different solution paths and supporting individual learning styles and knowledge construction.

**Gender Issue of Israeli students in Israeli National and International tests**

In National Israeli Math tests, for grade 5 gaps were found in favor of boys (about a quarter of standard deviation on average), and it seems to be expanding somewhat over the years 2012-2017.

At the same time in National Israeli Math tests, for grade 8, the achievements of boys and girls are similar throughout the years 2012-2017. The same picture is when comparing the achievements of Israeli boys and girls in TIMSS tests (2007,2011,2015).

The gap in favor to boys at an average of 16 points (about 1/6 of standard deviation on average) found again in the PISA tests in mathematics literacy in years 2006, 2009,2012. (Rapp, 2014)

In the following section we describe the Kangaroo Contest Virtual Training (KCVT) structure that allowed us to collect appropriate data.

**Structure of the Kangaroo Contest Virtual training (KCVT)**

The official aim of the KCVT is to help to motivated students to prepare themselves to International Kangaroo Contest. The hidden aim of the KCVT was to involve students to mathematical activity and to improve their mathematical thinking skills.

 According to our model of the KCVT, one set of 8 non-routine challenging problems was posted every week on the special website ([www.kangaroo4u.tik-tak.co.il](http://www.kangaroo4u.tik-tak.co.il)) during 16 weeks, from November, 2018 to March 2019. In total, 16 sets of 8 problems were offered to the participants. All problems were ordered according to increasing difficulty: sets 1-6 were defined as "easy level", sets 7-12 – "average level" and sets 13-16 – "high level".

Every registered member could login, choose a problem, solve it, and submit an answer by selecting it from a multiple-choice menu (5 distractors). The automatic scoring system immediately evaluated students' success producing a score for the problems and adjusting a total score that affected the overall standing.

Participants could join the KCVT, solve as many problems as they wished, withdraw, and come back at any time. The tasks were selected by a team of experts in mathematics and mathematics education from International Kangaroo Contest that were used in real Kangaroo competitions in previous years.

**The Study**

**Research Questions**

In this study, we use data from the KCVT stage to investigate the following research questions:

* Is there any difference between boys and girls regarding to persistence in their participation in KCVT?
* Are there any gender-related patterns in the participation of boys compared with girls according to different levels of difficulty?

**Methodology**

This research followed a quantitative methodology based on the analysis of an external database software. The implementation of T-tests and descriptive statistics enabled the researchers to compare several variables between girls and boys performance.

**Participants**

Every student who wanted to participate in the contest (possibly sometimes due to the encouragement of the students' parents) could do it without any early condition (such as a test or an interview). The students only needed to pay a very low registration fee. The students' ages ranged between 11 and 12 years old, and they came from different parts of Israel, from large cities as well as smaller cities and villages, and from different socioeconomic backgrounds. In total there were 1005 kids: 546 boys and 459 girls that took part in the KCVT.

**The results**

In order to investigate the first sub-question, we have collected and analysed the data about boys' and girls' participation for each of 16 sets. We collected and compared the numbers of initial enrolment and on-going visits for boys and girls separately.

In order to address the second sub-question, we have analysed the data about boys' and girls' attempts to solve either all or some particular problems from each set. For example, some students could attempt only the questions from easy level (sets 1-6). We were interested if the student was trying to stay in a 'safer' zone, or to take some greater 'risks' solving average level problems (sets 7-12) or even high level problems (sets 13-16). In this respect, we were curious whether a virtual problem solving environment had allowed girls to exhibit risk-taking behaviour at a rate comparable to the one of boys. We have compared the number of girls and boys among this group. The next section presents our findings.

Regarding the first research question, in Picture 1 we present the descriptive data according to boys' and girls' participation in KCVT. According to the data presented below, no differences were found between boys' and girls' behaviour in KCVT: at each set participated approximately the same per cents of boys and girls.

Picture 1. Boys and girls persistence in KCVT (in %)

Boys and girls per cents of participants were the same and it decreased in the same pattern: if with first set coped 82.2% boys and 81.1% girls, with the set N4 coped 41.4% of boys and 40.1% of girls, then with set N8: 26.9% of boys and 22.7% of girls, with set N12: 14.7% of boys and 13.1% of girls, and at the end with set N16: 1.8% of boys and 2.2% of girls.

 No differences were found between boys' and girls' per cents when coped with sets of different level of difficulty: easy (sets 1 – 6), average (sets 7 – 12), high (sets 13-16).

We also checked the per cents of boys and girls that submitted different number of tasks in total (1-16).

In Pic 2 we present the collected data:

Picture 2. Per cents of boys and girls per submitted tasks

The per cent of girls than submitted only one task (of 16) was bigger (but not significantly) than those of boys: 25.7% (girls) vs 23.1% (boys). In general, it means that about quarter of all participants left the training after first tasting of problems. After tasting 2 sets left the training additional 16.1% of girls and 16.8% of boys.

And after submitting 3 sets in total left the training 57.7% of girls and 51.3% of boys.

No gender differences were found in participants' persistent in KCVT.

In order to address the second sub-question, we have analysed the data about boys’ and girls’ means for all sets and then the means of sets of the same difficulty level.

In Table 1 we present the data according gender differences when coped with all tasks in 16 weeks.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Easy level |   |  | Gender |  |
| Boys | Girls |  |  |  |
| N | Mean (of 40) | Std. Deviation | Std. Error Mean | N | Mean (of 40) | Std. Deviation | Std. Error Mean | t | df | Sig.(2-tailed) |
| Set 1 | 449 | 25.66 | 10.048 | .474 | 372 | 26.26 | 10.128 | .525 | -.858 | 819 | .391 |
| Set 2 | 355 | 22.68 | 11.862 | .630 | 303 | 23.63 | 11.681 | .671 | -1.036 | 656 | .301 |
| Set 3 | 293 | 26.59 | 11.398 | .666 | 250 | 27.34 | 11.014 | .697 | -.779 | 541 | .436 |
| Set 4 | 226 | 22.04 | 12.241 | .814 | 184 | 20.92 | 12.009 | .885 | .922 | 408 | .357 |
| Set 5 | 197 | 25.48 | 12.233 | .872 | 147 | 24.76 | 11.767 | .971 | .549 | 342 | .583 |
| Set 6 | 177 | 25.93 | 12.368 | .930 | 136 | 24.34 | 11.528 | .989 | 1.175 | 300 | .241 |
| Average level |  |  |  |  |  |  |  |  |  |  |  |
| Set 7 | 148 | 22.87 | 14.047 | 1.155 | 104 | 21.63 | 13.062 | 1.281 | .717 | 231 | .474 |
| Set 8 | 147 | 21.56 | 12.792 | 1.055 | 104 | 20.58 | 13.534 | 1.327 | .588 | 249 | .557 |
| Set 9 | 126 | 21.75 | 13.059 | 1.163 | 83 | 22.77 | 11.589 | 1.272 | -.580 | 207 | .562 |
| Set 10 | 102 | 25.29 | 13.694 | 1.356 | 81 | 21.85 | 13.144 | 1.460 | 1.719 | 181 | .087 |
| Set 11 | 108 | 21.57 | 13.319 | 1.282 | 62 | 19.52 | 14.249 | 1.810 | .945 | 168 | .346 |
| Set 12 | 80 | 19.94 | 13.745 | 1.537 | 60 | 22.33 | 14.186 | 1.831 | -1.007 | 138 | .316 |
| High level |  |  |  |  |  |  |  |  |  |  |  |
| Set 13  | 65 | 19.62 | 12.909 | 1.601 | 55 | 19.18 | 12.389 | 1.671 | .187 | 118 | .852 |
| Set 14 | 42 | 18.57 | 13.981 | 2.157 | 29 | 17.41 | 14.244 | 2.645 | .340 | 69 | .735 |
| Set 15 | 24 | 23.75 | 13.126 | 2.679 | 33 | 19.39 | 12.104 | 2.107 | 1.295 | 55 | .201 |
| Set 16 | 10 | 12.00 | 14.181 | 4.485 | 10 | 15.50 | 13.427 | 4.246 | -.567 | 18 | .578 |

Table 1. The success rate of boys and girls at each set

From the data presented in Table 1 we revealed that no gender differences were found through all 16 sets. In Table 2 we present the data according gender differences when coped with different difficulty levels of tasks.

|  |  |  |  |
| --- | --- | --- | --- |
| Group Statistics & Independent Samples Test |  |  |  |
| Sets | GENDER |  |  |  |
| Boys | Girls |  |  |  |
| N | Mean (of 40) | Std. Deviation |  | N | Mean (of 40) | Std. Deviation |  |  |  |
| Easy 1-6 | 506 | 24.722 | 11.483 |  | 433 | 24.829 | 11.206 |  |  |  |
| Average 7-12  | 248 | 22.220 | 13.425 |  | 163 | 21.456 | 13.240 |  |  |  |
| High 13-16  | 82 | 19.469 | 13.365 |  | 68 | 18.541 | 12.847 |  |  |  |

Table 2. The success rate of boys and girls at each difficulty level

From the data presented in Table 2 we can recognize that no gender differences in achieved scores were found when students coped with different difficulty level of tasks.

We also compared the total number of boys and girls that got scores in 4 quarters (of possible 640 in total). In the Table 3 we present the findings:

|  |  |
| --- | --- |
|  | Gender |
| Boys | Girls |
|  | 1-160 | Count | 445 | 379 |
| % within  | 81.5% | 82.6% |
| 161-320 | Count | 54 | 52 |
| % within  | 9.9% | 11.3% |
| 321-480 | Count | 35 | 15 |
| % within  | 6.4% | 3.3% |
| 481-640 | Count | 12 | 13 |
| % within  | 2.2% | 2.8% |
| Total | Count | 546 | 459 |

Table 3. Per cents of boys and girls in 4 quarters of scores

No gender differences were found in this data.

**preliminary results and discussion**

There were 1005 students participated in at least one round (of the total of sixteen rounds) of the KCVT. There were more boys (546, or 54.33%) than girls (459, or 45.7%). Our data do not indicate any significant difference in participation according to the gender: girls seem to be as active as boys.

Further, Pic 1 and Pic 2 show how the number was changing over each round. We can conclude that the numbers of participated boys and girls are nearly the same in each of remaining sets. We can see therefore that girls who decided to continue participation were as persistent as boys.

The number of submitted tasks by gender, according to Pic 1 and Pic 2 shows that there was no significant difference in the number of attempts related to the difficulty levels between girls and boys. This observation is particularly valuable in view of the fact that in a regular classroom setting “teachers perceived that girls … produced fewer exceptional, risk-taking [learners] than did boys.” (Williams, 2006).

The dynamics of success rates is similar between the girls and the boys in all rounds (Table 1 and 2); also, both genders were more successful on easier levels and less in more difficult levels (average and high).

**Conclusions:**

The gender issue in mathematics, i.e., girls being underrepresented in the STEM-related fields, still remains unresolved. This is why every inclusive endeavour to popularize mathematics by attracting all students merits particular attention. Kangaroo Contest Virtual Training is exemplary of such inclusive competitions. With limited research available on the patterns of participation and the results of the contest, it is important to investigate gender-related issues. While analyzing the results of participants from Grades 5-6 in the 2018 Israeli KCVT, according to gender, we found, that there were no significant differences between boys' and girls' behaviour during the training.

We also found that there were no differences between the achievements of boys and girls while coping with problems of different levels of difficulty. These results are consistent with earlier researches that also revealed no gender differences in mathematical performance (Ajai & Imoko, 2015, Applebaum et al., 2013, Devine et al., 2012).

The data do not yield any far-reaching conclusions about the factors that might explain these findings.

Some other aspects like parents' encouragement to participate and gender issues in using technology should be taken into an account in next research.

Yet, it is worthwhile to conduct further research and analysis over the next few years to see if the pattern re-appears. Furthermore, deeper analysis is needed regarding the tasks that were solved better by girls and the methods they used in solving them.

Our preliminary data analysis has several limitations, the major being that we did not see students’ solutions and we don't know the reason why part of them left the training. We also don't know if participants got help from their families/internet sources/book sources. Nevertheless, we observe similar participation rate, risk taking behaviour and persistence for both genders. This gender similarity is consistent with other researchers’ finding (Lloyd et al., 2005; Williams, 2006) indicating non-significant gender difference at the junior high level mathematics as well as equal abilities and interest of both boys and girls to participate in on-line activities.

Our future work will use more data and look at more detailed data analysis including students’ interviews that could reveal the reasons of students’ behaviour and insightful comments about their thoughts and attitudes during this on-line problem solving activity.

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