Gender issues in virtual training for the Mathematical Kangaroo Contest

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In today’s technologically enhanced world, mathematics competitions have become accessible to more boys and girls interested in challenging tasks. During our analysis of the final stage of the Mathematical Kangaroo Contest in Israel, we were focused on the issue of attracting girls to mathematics generally, and math competitions specifically. We found that boys showed better results. Further analysis of the differences across Grades 2–6 indicated the gap between boys and girls was smaller in some grades than others. No significant differences were observed in Grade 4 among all difficulty levels. Furthermore, across all five grades, the girls' performance on some tasks was better than that of the boys. Further investigation is required to ascertain the existence of a particular trend, and the possible underlying factors. We considered gender-related issues pertinent to virtual training for the Israeli Mathematical Kangaroo Contest in Grades 5 and 6. We evaluated whether any differences existed in participation patterns between boys and girls, and their performance in online problem-solving programmes.

Keywords: gender, online mathematics competitions, challenge, problem-solving

# Introduction

Many educators express concern about the gender gap in mathematics performance and the under-representation 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 and Mertz 2009).

Several researchers have highlighted mathematics performance in favour of boys (Aunola et al. 2004; Githua and Mwangi 2003; Marsh et al. 2008), whereas others (Lindberg et al. 2010) have 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 than boys in mathematics.

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 competitions? Niederle and Vesterlund (2010) found that gender differences in competitive performance are not reflective of differences in non-competitive performance. Gneezy et al. (2003) even revealed that the gender gap in performance under competitive conditions is three times greater than under non-competitive conditions. Leedy, LaLonde, and Runk (2003) studied the 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 to develop strategies aimed at providing gender-equitable education. However, there is insufficient data regarding how gender-related differences are manifested in mathematics competitions and the patterns that 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 the present study, we analyse the performance of boys and girls in the first stage of the 2018 Israeli competition (as part of the International Kangaroo Contest). Students participated in online internet training over 16 weeks, during which they had to identify themselves, at home, or sometimes at 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 organised in different formats, in different venues and for different types of students. They are considered ‘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 inspire many children and young adults. Bicknell (2008) found the use of competitions in mathematics programmes to have numerous advantages, such as student satisfaction, enhancement of self-directed learning skills among the students, increased sense of autonomy, and cooperative teamwork skills. Robertson (2007) reported that success in mathematics competitions, and mathematics achievements in general, seem to be linked to the appreciation and interest instilled during the students’ learning experience. Mathematics competitions also provide an opportunity to acquire high-level skills with extra training and facilitates 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 various competitions, the Kangaroo Contest stands out because of its main objective: the popularisation of mathematics with the special purpose of showing young participants that mathematics can be interesting, beneficial and even fun (Kenderov et al., 2009). The target population of the Kangaroo Contest is not limited to the most mathematically talented students; rather, it aims to attract as many students as possible. Although it has been generally accepted that the vast majority of people find mathematics difficult, very abstract and unapproachable, the number of competitors in the contest proves that this need not be the case. As it attracts a substantial number of competitors, the contest helps to eradicate such prejudice towards mathematics.

Choosing appropriately challenging tasks is an important condition for the successful contribution of mathematical competitions to developing the learning potential of students (Bicknell 2008). In contrast to other more challenging competitions, the mathematical problems in the Kangaroo Contest are more appropriate, and based on the challenging task concept suggested by Leikin (2009). Such tasks should be neither too easy nor too difficult, to motivate students and develop their mathematical curiosity and interest in the subject.

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

# Gender-related data on mathematics competitions: is there an issue?

Several educators express concern regarding gender differences in mathematics performance and the under-representation of women in STEM careers (National Academy of Science 2006; Hyde et al. 2008). Gender inequity is particularly evident in data related to the number of girls participating in the International Math Olympiad, or the number of female professors in the mathematics and engineering departments of universities (Hyde and Mertz 2009). This problem can be addressed in several ways.

First, psychologists look for gender differences in brain structure, hormones, the use of the brain’s hemispheres, nuances of cognitive or behavioural development, and consequent spatial and numerical abilities that may predispose males to a greater aptitude for, and success in mathematics (Halpern 1997; Moir and Jessel 1989). However, several relevant findings in the literature are inconsistent (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 recorded by educators at different stages of schooling, in an attempt to identify when the gender gaps in mathematics first occur, as well as further dynamics of the gap. 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, more current data provide no evidence of a gender difference favouring males 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, and Yailagh 2005, p. 385). Research that views gender differences through the lens of the attribution theory (e.g. Bandura 1997) suggests that girls tend to attribute their math successes to external factors and efforts, and their failures to their own lack of ability (self-defeating pattern); whereas boys tend to attribute their successes to internal factors, and their failures to external factors (self-enhancing pattern). It is better for an individual to attribute success to ability, rather than effort, because ability attributions are more strongly related to motivation and skill development (Schunk and Gunn 1986). These patterns partially explain the poorer achievement of girls (Lloyd, Walsh, and Yailagh 2005).

 According to Asante (2012), the attitudes of secondary students towards mathematics are influenced by a set of factors including the ‘school environment, teachers’ attitudes and beliefs, teaching styles and behaviour and parental attitudes towards mathematics’. That study was focused on girls being discouraged from studying math, and strongly argued that girls receive less encouragement and support in the classroom than boys. Williams (2006) showed that many classrooms create an atmosphere of competition among students. Such an atmosphere plays to the strength of boys, who are socialised to compete, but often intimidates girls, who are more often socialised to collaborate.

 The third way to address 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. With regards to mathematical performance, parents tend to have greater expectations for sons than they have for daughters, and this influences the students’ results (Leder, 1993). Even talented and motivated girls ‘are not immune to the ill effects of gender bias’ (Leedy, LaLonde, and Runk 2003, p. 290). In this respect, it is unfortunate that the stereotypes that girls and women lack mathematical ability persist and are widely held by parents and teachers (Hyde et al. 2008).

Leedy, LaLonde, and Runk (2003) studied the 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 domain by men, while girls and women fail to acknowledge the existence of the bias. Other researchers have found interesting results showing that gender differences in mathematics performance are declining, or non-existent in gender-equal countries (Else-Quest, Hyde, and Linn 2010; Guiso, Monte, and Sapienza 2008). Leedy, LaLonde, and Runk (2003) also argue that the task of the school is not to ignore or deny differences in learning styles, attitudes and performance, but acknowledge and use them to develop strategies aimed at providing gender-equitable education.

In conclusion, in all three perspectives in research on gender in mathematics – cognitive, instructional and socio-cultural – careful consideration of how the data are collected, examined and interpreted is necessary. This is because no single approach provides a fully consistent theory that could explain the existing gender differences observed at a 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 the previous section summarises research related to gender issues in mathematics education that show no conclusive findings, similar observations can be drawn from technology-related studies that we will review briefly. Fogasz (2006) reports that when referring to classroom practices that involve computers as a learning tool, mathematics teachers held gender-based beliefs about their students. They assumed that the incorporation of technology has more positive effects on male classroom engagement and their affective responses, and thus, the technological approach was more beneficial to learning in boys.

At the same time, Wood, Viskic, and Petocz (2003) found no gender differences in the use of computers among students, nor in their attitudes towards the use of computers. This agrees with ideas expressed by Williams (2006) quoted above, who reviewed studies, which showed that girls are just as confident and active as boys in creating webpages, writing blogs, reading websites, and chatting online, among other activities.

As mentioned in the publications of Freiman et al. (2009) and Freiman and Applebaum (2009), the internet can be a suitably challenging environment on which mathematics competitions and problem-solving activities can be organised, and can potentially contribute to the development of mathematical ability and giftedness. In a recent analysis of middle-school students participating in a web-based mathematics competition, Carreira et al. (2012) argued that although one cannot conclude that by solving problems online, students do better in mathematics, their data provides evidence that the use of technology tends to involve more complex mathematical thinking.

As one among a powerful set of extra-curricular activities, such as mathematical clubs, mathematical camps and mathematics competitions (Olympiads), online mathematics competitions play a significant role in nurturing interest and motivating young learners of mathematics, as well as identifying and fostering the most capable and talented (Bicknell 2008; Karnes and Riley 1996; Robertson 2007; Skvortsov 1978).

The choice of appropriately challenging tasks is also an important condition for the success of mathematics competitions in developing the learning potential of students. The tasks should motivate students to persevere with task completion and develop mathematical curiosity and interest in the subject. Furthermore, tasks 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. They should also support individual learning styles and the further development of knowledge.

# Gender issues among Israeli students in Israeli national and international tests

In National Israeli Math tests, for Grade 5, gaps were found in favour of boys (about a quarter of standard deviation on average), which seemed to have expanded somewhat over the years 2012–2017. For Grade 8, the achievements of boys and girls in National Israeli Math tests are similar throughout the years 2012–2017. A similar trend is observed when comparing the achievements of Israeli boys and girls in the Trends in International Mathematics and Science Study (TIMSS) (2007, 2011 and 2015).

The gap in favour of boys by an average of 16 points (about 1/6 of standard deviation on average) was again observed in the PISA tests in mathematics literacy in the years 2006, 2009 and 2012 (Rapp 2014). In the following section we describe the structure of the Kangaroo Contest Virtual Training (KCVT), which allowed us to collect the appropriate data.

# Structure of the Kangaroo Contest Virtual Training (KCVT)

The official aim of the KCVT is to motivate students to prepare themselves for the International Kangaroo Contest. The hidden aim of the KCVT is to get students more involved in mathematical activities and improve their mathematical thinking skills.

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

Every registered member was able to login, choose a problem, solve it, and submit an answer by selecting it from a multiple-choice menu (with five distractors). The automatic scoring system immediately evaluated the performance of the students by producing a score for the problems and adjusting the total score, which affected the overall standing.

Participants could join the KCVT, solve as many problems as they wished, withdraw, and return at any time. The tasks were selected by a team of experts in mathematics and included material from previous tests of the International Kangaroo Contest.

# The study

## Research questions

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

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

# Methods

A quantitative methodology was followed 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 the performance of girls and boys, respectively.

## Participants

Every student who opted to participate in the contest (possibly due to the encouragement of parents) could do so without conditions (such as a test or interview). The only requirement was that students pay a very low registration fee. The age range of the students was between 11 and 12 years, and they came from various regions of Israel, including large cities as well as smaller cities and villages, and different socioeconomic backgrounds. In total, there were 1005 children, 546 boys and 459 girls, who took part in the KCVT.

# Results

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

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

Regarding the first research question, in Figure 1 we present the descriptive data regarding the participation of boys and girls in the KCVT. According to our findings, no differences were observed between the behaviour of boys and girls in the KCVT. For each set, the level of participation was approximately the same for boys and girls.

[Figure 1 near here]

The percentage of participants among boys and girls showed similar trends, and decreased in a similar pattern as follows: in the first set, 82.2% of the boys and 81.1% of the girls participated; in the N4 set, 41.4% of the boys and 40.1% of the girls participated; in the N8 set, 26.9% of the boys and 22.7% of the girls participated; in the N12 set, 14.7% of the boys and 13.1% of the girls participated, and at the end, in the N16 set, 1.8% of the boys and 2.2% of the girls participated.

 No differences were found between the participation of boys and girls among specific sets of different levels of difficulty, including the easy (sets 1–6), average (sets 7–12), and high (sets 13–16) levels. We also evaluated the percentage of boys and girls who submitted different numbers of tasks in total (1–16). In Figure 2 we present the collected data.

[Figure 2 near here]

The percentage of girls who submitted only one task (out of 16) was larger (but not significantly so) than that of boys (25.7% [girls] vs. 23.1% [boys]). In general, this means that about quarter of all participants left the training after the first set of problems. After the first two sets of problems, an additional 16.1% of the girls and 16.8% of the boys left the training. After submitting a total of three sets, 57.7% of the girls and 51.3% of the boys left the training. No gender differences were observed in the persistence of participants in the KCVT.

In order to address the second sub-question, we analysed the data regarding the mean values for boys and girls among all sets, and then evaluated the means among sets of the same difficulty level. In Table 1, we present the data based on the gender differences among all participants who attempted the tasks over 16 weeks.

[Table 1 near here]

Based on the data presented in Table 1, no gender differences were found in any of the 16 sets. In Table 2, we present the data based on gender differences among the different levels of difficulty of the tasks.

[Table 2 near here]

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Based on the data presented in Table 2, no gender differences in scores were found when students attempted tasks of different levels of difficulty. We also compared the total number of boys and girls who achieved scores in four quartiles (out of a total of 640). In Table 3, we present those findings. No gender differences were found in this data.

[Table 3 near here]

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# Preliminary Results and Discussion

A total of 1005 students participated in at least one round (out of a total of 16 rounds) of the KCVT. More boys (546, or 54.33%) participated than girls (459, or 45.7%). Our data showed no significant differences in participation based on gender; girls seemed to have been just as active as boys.

Furthermore, Figures 1 and 2 show the change in the level of participation over each round. We can conclude that the numbers of boys and girls who participated in the training was nearly the same in each sets. Thus, the girls who decided to continue participation were just as persistent as the boys.

The number of tasks submitted by gender, according to Figures 1 and 2 shows no significant differences between girls and boys in the number of attempts, as it relates to the level of difficulty. This observation is particularly important, 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 the success rates were similar between the girls and boys in all rounds (Tables 1 and 2). In addition, both sexes were more successful on easier levels and less successful in the more difficult levels (average and high).

# Conclusions

The gender issue in mathematics, i.e., girls being under-represented in the STEM-related fields, remains unresolved. Thus, every inclusive endeavour to popularise mathematics by attracting all students merits particular attention. The KCVT is a fine example 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. Following our analysis of the results of participants from Grades 5–6 in the 2018 Israeli KCVT, we found no significant differences between the behaviour of boys and girls during the training.

We also found no differences between the achievements of boys and girls who attempted problems with different levels of difficulty. These results are consistent with earlier studies that have also shown no gender differences in mathematical performance (Ajai and Imoko 2015; Applebaum et al. 2013; Devine et al. 2012).

However, the data yield no far-reaching conclusions about the factors that might explain these findings. Other aspects, such as encouragement from parents to participate and gender issues in the use of technology should be considered in future studies. Furthermore, further research and analysis over the next few years would be worthwhile, to determine whether the pattern re-appears. Deeper analysis is required regarding the tasks that were solved more efficiently by girls and the methods they used to solve those tasks.

Our preliminary data analysis has several limitations. The major limitation is our inability to see the solutions of the students. We also are not aware of the reasons for the early departure of some students from the training. Furthermore, we do not know whether participants were assisted by family members/internet sources/book sources. Nevertheless, we observed similar participation rates, risk-taking behaviours and persistence among both genders. This similarity is consistent with the findings of other researchers (Lloyd, Walsh, and Yailagh 2005; Williams 2006), who reported non-significant gender differences in mathematics at the junior high-level, as well as equal abilities and interest among both boys and girls during their participation in online activities.

Our future work will use more data and look at more detailed analyses, including interviews with students, which could reveal the reasons for their behaviour, and insightful comments about their thoughts and attitudes during this online problem-solving activity.

**References**

Ajai, J. T., and I. I. Imoko. 2015. “Gender Differences in Mathematics Achievement and Retention Scores: A Case of Problem-Based Learning Method.” *International Journal of Research in Education and Science (IJRES)* 1 (1): 45–50.

Asante, K. O. 2012. “Secondary Students' Attitudes Towards Mathematics.” *IFE Psychologia: An International Journal* 20 (1): 121–133.

Bandura, A. 1997. *Self-efficacy: The Exercise of Control*. New-York: Freeman.

Bicknell, B. 2008. “Gifted Students and the Role of Mathematics Competitions.” *Australian Primary Mathematics Classroom* 13 (4): 16–20.

Carreira, S., N. Amado, R. Ferreira, and J. Carvalho e Silva. 2012. “A Web-Based Mathematical Problem Solving Competition in Portugal: Strategies and Approaches.” Accessed 21 September 2012. <http://www.icme12.org/upload/UpFile2/TSG/1405.pdf>

Devine, A., K. Fawcett, D. Szűcs, and A. Dowker. 2012. “Gender Differences in Mathematics Anxiety and the Relation to Mathematics Performance While Controlling for Test Anxiety.” *Behavioral and Brain Functions* 8: 33.

Fomin, D., S. Genkin, and I. Itenberg. 2000. “Mathematical Circles: Russian Experience.” (Mathematical World, Vol. 7), American Mathematical Society.

Freiman, V., and M. Applebaum. 2009.“Involving Students in Extra-Curricular School Mathematical Activity: Virtual Mathematical Marathon Case Study.” In: *In Search for Theories in Mathematics Education.* *Proceedings of the 33rd Conference of the International Group for the Psychology in Mathematics Education*, edited by M. Tzekaki, M. Kaldrimidou, and H. Sakonidis, 1: 203–205.

Freiman, V., and M. Applebaum. 2011. “Online Mathematical Competition: Using Virtual Marathon to Challenge Promising Students and to Develop Their Persistence.” *Canadian Journal of Science, Mathematics and Technology Education* 11 (1): 55–66.

D. G. S. andI. “”*Challenging Mathematics in and Beyond the Classroom.* *The 16th ICMI Study. New ICMI Study Series, Vol. 12.*,edited by , and

Guiso L., F. Monte, and P. Sapienza. 2008. “Differences in Test Scores Correlated With Indicators of Gender Equality.” *Science* 320: 1164–1165.

Halpern, D. F. 1997. “Sex Differences in Intelligence. Implications for Education.” *American Psychologist* 52: 1091–1102.

Halpern, D. F., C. P. Benbow, D. C. Geary, and R. C. Gur. 2007. “The Science of Sex Difference in Science and Mathematics. *Psychological Science in the Public Interest* 8 (1): 1–51.

Hyde, J. S., S. M. Lindberg, M. C. Linn, A. B. Ellis, and C. C. Williams. 2008. “Gender Similarities Characterize Math Performance.” *Science* 321: 494–495.

Hyde, J. S., and J. E. Mertz. 2009. “Gender, Culture, and Mathematics Performance.” *Proceedings of the National Academy of Sciences of the United States of America* 106 (22): 8801–8807.

Johnson, D. 2000. “Teaching Mathematics to Gifted Students in the Mixed-Ability Classroom.” ERIC Digest 594.

Jones, K., and H. Simons. 2000. “The Student Experience of Online Mathematics Enrichment.” In *Proceedings of the 24th Conference of the International Group for the Psychology of Mathematics Education*, *July 2000*, edited and3: 103–110. Hiroshima: PME.

Karnes, F. A., and T. L. Rilley. 1996. “Competitions: Developing and Nurturing Talents.” *Gifted Child Today Magazine*, 24 (4): 14–15.

Else-Quest, N. M., J. S. Hyde, and M. C. Linn. 2010. “Cross-national Patterns of Gender Differences in Mathematics: A Meta-Analysis.” *Psychological Bulletin* 136 (1): 103–127.

Leder, G. C. 1993. “Mathematics and gender.” In *Handbook of Research on Mathematics Teaching and Learning*, edited by ,597–622. Reston, VA: National Council of Teachers of Mathematics.

Leedy, M. G., D. LaLonde, and K. Runk. 2003. “Gender Equity in Mathematics: Beliefs of Students, Parents, and Teachers.” *School Science and Mathematics* 103 (6): 285–292.

Leikin, R. 2004. “Towards High Quality Geometrical Tasks: Reformulation of a Proof Problem.” In *Proceedings of the 28th International Conference for the Psychology of Mathematics Education*, edited by , and,Vol. 3, 209–216*.*

Leikin, R. 2007. “Habits of Mind Associated with Advanced Mathematical Thinking and Solution Spaces of Mathematical Tasks.” *The* *Fifth Conference of the European Society for Research in Mathematics Education* - *CERME-5*, 2330–2339 (CD-ROM and Online). Accessed 22 September 2012. <http://ermeweb.free.fr/Cerme5.pdf>

Lloyd, J. E. V., J. Walsh, and M. S. Yailagh. 2005. “Sex Differences in Performance Attributions, Self-Efficacy and Achievement in Mathematics: If I’m So Smart, Why Don’t I Know It?” *Canadian Journal of Education* 28 (3): 384–408.

Moir, A., and D. Jessel. 1989. *Brain Sex.* *The Real Difference Between Men and Women*. New York: Dell Publishing.

National Academy of Science. 2006. *Beyond Bias and Barriers: Finding the Potential of Women in Academic Science and Engineering.* Washington, DC: National Academic Press.

National Council of Teachers of Mathematics. 2000. *Principles and Standards for School Mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Renninger, K. A., and W. Shumar. 2004. “The Centrality of Culture and Community to Participant Learning at the Math Forum.” In *Designing for Virtual Communities in the Service of Learning*, edited by and, 181–209*.* England: Cambridge University Press.

Robertson, B. 2007. *Math Competitions: A Historical and Comparative Analysis.* Accessed 15 April 2010. <http://dspace.nitle.org/bitstream/handle/10090/13996/1087.pdf?sequence=1>

Schunk, D. H., and T. P. Gunn. 1986. “Self-Efficacy and Skill Development: Influence of Task Strategies and Attributions*.*” *Journal of Educational Research* 79 (4): 238–244.

Skvortsov, V. 1978. “Mathematical Olympiads.” In *Socialist Mathematics Education*, edited by F. Swetz, 351–370. Southampton, PA: Burgundy Press.

Spelke, E. S. 2005. “Sex Differences in Intrinsic Aptitude for Mathematics and Science?” *American Psychologist* 60: 950–958.

Sullenger, K., and V. Freiman. 2011. “Choosing to Study Mathematics and Science Beyond the Classroom: Who Participates and Why?” In *Interdisciplinarity for the 21st Century*, edited by , and, 441–464.Charlotte, NC: Information Age Publishing.

Taylor, P., F. Gourdeau, and P. Kenderov. 2004. *The Role of Competitions in Mathematics Education*. Accessed15 <http://www.amt.edu.au/icme10dg16proc.html>

Williams, B.T. 2006. “Girl Power in a Digital World: Considering the Complexity of Gender, Literacy and Technology.” *Journal of Adolescent and Adult Literacy* 50 (4): 300–307.

sfor of mathematical problems

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| 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 | 0.474 | 372 | 26.26 | 10.128 | 0.525 | -0.858 | 819 | 0.391 |
| Set 2 | 355 | 22.68 | 11.862 | 0.630 | 303 | 23.63 | 11.681 | 0.671 | -1.036 | 656 | 0.301 |
| Set 3 | 293 | 26.59 | 11.398 | 0.666 | 250 | 27.34 | 11.014 | 0.697 | -0.779 | 541 | 0.436 |
| Set 4 | 226 | 22.04 | 12.241 | 0.814 | 184 | 20.92 | 12.009 | 0.885 | 0.922 | 408 | 0.357 |
| Set 5 | 197 | 25.48 | 12.233 | 0.872 | 147 | 24.76 | 11.767 | 0.971 | 0.549 | 342 | 0.583 |
| Set 6 | 177 | 25.93 | 12.368 | 0.930 | 136 | 24.34 | 11.528 | 0.989 | 1.175 | 300 | 0.241 |
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| Set 7 | 148 | 22.87 | 14.047 | 1.155 | 104 | 21.63 | 13.062 | 1.281 | 0.717 | 231 | 0.474 |
| Set 8 | 147 | 21.56 | 12.792 | 1.055 | 104 | 20.58 | 13.534 | 1.327 | 0.588 | 249 | 0.557 |
| Set 9 | 126 | 21.75 | 13.059 | 1.163 | 83 | 22.77 | 11.589 | 1.272 | -0.580 | 207 | 0.562 |
| Set 10 | 102 | 25.29 | 13.694 | 1.356 | 81 | 21.85 | 13.144 | 1.460 | 1.719 | 181 | 0.087 |
| Set 11 | 108 | 21.57 | 13.319 | 1.282 | 62 | 19.52 | 14.249 | 1.810 | 0.945 | 168 | 0.346 |
| Set 12 | 80 | 19.94 | 13.745 | 1.537 | 60 | 22.33 | 14.186 | 1.831 | -1.007 | 138 | 0.316 |
| High level |  |  |  |  |  |  |  |  |  |  |  |
| Set 13  | 65 | 19.62 | 12.909 | 1.601 | 55 | 19.18 | 12.389 | 1.671 | 0.187 | 118 | 0.852 |
| Set 14 | 42 | 18.57 | 13.981 | 2.157 | 29 | 17.41 | 14.244 | 2.645 | 0.340 | 69 | 0.735 |
| Set 15 | 24 | 23.75 | 13.126 | 2.679 | 33 | 19.39 | 12.104 | 2.107 | 1.295 | 55 | 0.201 |
| Set 16 | 10 | 12.00 | 14.181 | 4.485 | 10 | 15.50 | 13.427 | 4.246 | -0.567 | 18 | 0.578 |

|  |
| --- |
| df, degrees of freedom Table 2. Success rates of boys and girls at each difficulty level of mathematical tasksGroup statistics and independent samples test |
| Sets | Gender |
| Boys | Girls |
| N | Mean (of 40) | Std. Deviation |  | N | Mean (of 40) | Std. Deviation11.20613.24012.847 |
| Easy 1–6 | 506 | 24.722 | 11.483 |  | 433 | 24.829 |
| Average 7–12  | 248 | 22.220 | 13.425 |  | 163 | 21.456 |
| High 13–16  | 82 | 19.469 | 13.365 |  | 68 | 18.541 |

Table 3. Percentage of boys and girls within four quartiles of scores

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

Figure 1. Persistence of boys and girls in the Kangaroo Contest Virtual Training (KCVT)

Figure 2. Percentage of boys and girls per completed tasks