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Factors Driving Student Success on the 2015 PISA Tests

The Results from Israel

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Abstract

Since 2000, the PISA research surveys have been examining mathematics, science and reading literacy among 15-year olds in tens of countries. This report focuses on the 2015 PISA research which examined these three areas of literacy, and focuses specifically on science literacy (a new area was added in the 2015 research: collaborative problem-solving). The students also complete questionnaires regarding their attitudes towards the sciences: interest in science and technology, positive opinion of scientific approaches to research, and environmental awareness.

The PISA research examines the extent to which students have acquired comprehension and thinking skills in the areas tested, in a manner that provides them with tools to cope well and effectively in their environment. The research does not necessarily reflect the knowledge and content of the curriculum of each participant country. In addition to the literacy tests, the students and the principals of schools participating in the survey complete questionnaires on background variables likely to influence literacy attainments. For example, students provide background information about themselves, their families, their academic environment, and about science studies. The school principal questionnaire includes questions about the school and its resources, its students, teacher and teaching characteristics, school climate, patterns of work, and policy on various topics.

The present report is based on a study conducted by McKinsey, one of the leading strategic consulting firms in the world, executing research in public and private sectors. The objective of the McKinsey study (Dorn et al., 2017) was to identify the elements that most strongly influence student achievement in the sciences. In this context, students' thinking patterns were examined (motivation and interest in science), as were teaching methods, use of technological methods, number of teaching hours, etc. McKinsey produced reports for different areas of the world and the report referred to here focused on results in the Middle East. Unfortunately, the report related only to science literacy and does not include the results from Israel. In consequence, the need arose for a study that would focus on the findings for mathematics literacy in Israel.

Earlier findings (RAMA*, 2017) showed that Israel ranked in 39th place out of the 70 countries and economic entities that participated in the 2015 PISA research,

* National Authority for Measurement and Evaluation in Education

with an average score in mathematics literacy of 470 points (standard deviation = 103). Israel is likewise ranked in 40th place (out of 70) in science literacy with an average score of 467 points ((standard deviation = 106). With respect to attitudinal variables, students in Israel report that their internal motivation for science study is slightly higher than average for OECD countries and yet, Israel's place with respect to internal motivation is 43 out of 70. Israeli students express much less interest in areas of general science than average for OECD countries. Israel is ranked 65 out of 70 on this variable. At the same time, Israeli students report a higher level than average for OECD countries of daily activities in the area of science. Here, Israel ranks 45 out of 70.

Thinking patterns of students

The most prominent findings in the present report show that thinking patterns, beliefs, perceptions, attitudes and motivation with respect to learning, in general and science and mathematics studies, in particular, greatly impact performance on mathematics tests. Two patterns of thinking can be identified: subject-oriented thinking patterns, that is, an orientation toward the subject studied (for instance, motivation to learn science and mathematics), which accounts for 25% of the variance in mathematics literacy scores; and, general patterns of thinking that are related to learning motivation in general, and which account for 19% of the variance in mathematics literacy scores. Home environment includes factors such as parents' education level and socioeconomic background, and accounts for 32% of the variance in scores.

General thinking patterns include: calibration motivation – the degree to which a student is able to identify the daily activities necessary for realizing academic objectives; achievement motivation – the student's desire to succeed academically and to attain high grades; instrumental motivation – the student's belief that science is necessary and desirable to his or her future and to the career he or she will choose; test anxiety – the student's level of anxiety in test-taking.

It was found that high calibration, instrumental, and achievement motivation, along with low test anxiety are related to higher mathematics literacy scores. Similarly, lower mathematics literacy scores are related to lower calibration, instrumental or achievement motivation, along with high test anxiety.

Most students (60%) have strong calibration motivation except for students attending ultra-Orthodox-supervised schools, most of whom (53%) have weak calibration motivation. In all population sectors, most students (79%) have strong achievement motivation. There is also a higher proportion (55%) of students with strong instrumental motivation, except for students attending ultra-Orthodox-supervised schools, most of whom (77%) have weak instrumental motivation. At the school level, it appears that strong calibration motivation is higher among students from higher socioeconomic (SES) backgrounds and in schools where scores in mathematics literacy are higher. In due course, it was found that the results for calibration, instrumental, and achievement motivation were all similar and we will therefore relate to them below as a single variable.

In each SES group, for the general population of students and for Hebrew speakers in particular, motivation had great weight in mathematics literacy – strongly-motivated students demonstrate greater success than weakly-motivated students.

Comparison between male and female students in Israel shows that the average score of male students in mathematics literacy is slightly higher than that of female students (474 vs. 466, respectively). In general, a higher percentage of female students, as opposed to male students, reported strong calibration and achievement motivation (a disparity of 12% and 6%, respectively), while the proportion reporting strong instrumental motivation was higher by 4% for male students.

Among students with weak motivation (whether calibration, instrumental, or achievement) or with high test anxiety, there is essentially no difference between male and female students on scores in mathematics literacy. However, among students with high calibration, achievement, or instrumental motivation or low test anxiety, male students reach higher attainments than female students in mathematics literacy (differences of 27, 19, 24, and 10 points, respectively).

Similar to the results on other tests in mathematics (Meitzav,** TIMSS, psychometric), it was found that the average score for Hebrew-speakers was higher than those of Arabic-speakers (497 vs. 394, respectively). The proportion of those reporting strong calibration motivation was higher among Hebrew-speakers (65%) than Arabic-speakers (45%). A similar percentage of Hebrew- and Arabic-speaking students reported strong achievement motivation (77% and 79%, respectively). In contrast, a higher percentage of Arabic-speakers report strong instrumental motivation (74% vs. 49% for Hebrew-speakers).

Among these two language sectors and in schools under various supervision frameworks, students with strong motivation demonstrate greater success in mathematics literacy than students with weak motivation. For example, the difference in scores between students with strong or weak calibration motivation stands at 52 points (state supervision), 54 points (state-religious supervision), and 37 points (ultra-Orthodox supervision). Similar, though weaker, results were found with respect to the other two types of motivation.

With reference to Arabic-speaking students, it appears that the average score of students with strong motivation from low SES backgrounds is higher than the score of students with weak motivation from high SES backgrounds (this pattern was not found among Hebrew-speaking students). This finding is similar to results in other regions of the world and attests to high motivation being equal in weight to a jump from a low to a high SES background, illustrating the importance of motivation in advancing populations from low SES backgrounds.

** Growth and Effectiveness Measures for Schools

Teaching practices

This report focuses on two types of methods for teaching science: standard, frontal instruction, known as teacher-directed instruction, and inquiry-based teaching. Teacher-directed instruction refers to the frequency with which the teacher explains and demonstrates scientific ideas, discusses the students' question, and leads class discussions. Inquiry-based teaching refers to the degree to which the students in the class take an active role and participate in creating the discussions and deliberations in the classroom. That is, the frequency with which the students raise research questions, plan experiments in order to test their hypotheses, derive conclusions from their results, and discuss their experiences in class.

The report findings show that mathematics literacy scores increase the more each one of these methods is used separately. For example, the average score of students who reported on minimal frequency of teacher-directed instruction was 54 points lower than students who reported that the method was used in almost all of the lessons. Similarly, the average score of students who reported on minimal frequency of inquiry-based teaching was 87 points lower than those who reported that the method was used in almost all lessons. Like the findings in the McKinsey report (Dorn et al., 2017), in Israel the "perfect blend" of the two teaching practices that leads to the greatest improvement in mathematics literacy is high frequency of teacher-directed instruction and moderate frequency of inquiry-based teaching. About 22% of students reported such a blend, and their average score in mathematics literacy was 95 points higher (one full standard deviation) than the scores of students who reported on low frequency of the two types of teaching practices.

Computer use: The report findings show that in Israel, similar to other countries participating in the PISA survey, adding technological equipment to classrooms has a minor, and even negative, effect on average scores in mathematics literacy.

Teaching hours: Adding teaching hours does not necessarily constitute an effective means for improving achievement (study hours refers to study of all subjects). In Israel, similar to other countries, in schools where students study between 5.5 to 6 hours daily on average, students' achievements in mathematics literacy is 73 points higher than in schools that study fewer than four hours a day. Schools with a school day longer than six hours, however, negatively affect achievement. In practice, there is a moderate decline in scores as the number of hours over six increases.