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What Motivates Students to Invest and Excel in Mathematics and Science Studies in Middle School

Dr. Hagar Lerman

Liat Atzmon Hecht

NATIONAL INSTITUTE FOR TESTING & EVALUATION

Abstract

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The objective of this research is to examine what motivates students to invest and excel in mathematics and science study in middle school (grades 7-9). Different theories address motivation, in general and learning motivation, in particular. The questionnaire constructed for this study was based on a review of the literature and focused on the following types of motivation:

a. **Achievement motivation** – the desire to succeed and to attain high achievements;
b. **External motivation** –the desire to succeed in order to meet the surrounding environment's demands or expectations or to receive an external reward;
c. **Instrumental motivation** –the belief that studying is critical to the future and acceptance to preferred career paths;
d. **Internal motivation** –the interest, satisfaction, and enjoyment of learning with no need of reward and no need of external incentives;
e. **Calibration motivation** –the identification of daily activities required in order to attain academic goals and how much effort to invest so as to succeed.

317 middle school students responded to an online survey in an internet panel. Below are the main findings and insights that describe the motivations that influence middle school students to invest and excel in their mathematics and science studies.

Main insights – Mathematics

It appears that the main factor motivating middle school students to persevere in their mathematics studies is the aspiration to succeed, and the concrete manifestation of their success - in a test grade. Students believe that mathematics is necessary to their future. They are motivated by both external and internal motivations, beginning with the need to meet the demands of their surroundings ("The teacher checks the homework", "My parents want me to be in a high ability grouping", "My parents will be happy if I get a good grade") and ending with internal motivation (challenge, satisfaction, interest).

Emerging from the students' responses to the questionnaire, we see that about half know that to succeed they must invest effort, and they know how much effort they need to invest. The rate of students who are willing to invest the effort to succeed, however, is lower (about a third of all students). It is probable that these types of motivation develop with age and with the number of years in the education system, as seen from the differences between the responses of 7th and 8th grade graduates and from 9th grade graduates.

Attribution of failure is largely external ("The teacher didn't explain the material well", "I studied but I still failed"), but is accompanied by a feeling of disappointment ("I'm disappointed because I actually thought it went well for me", "Why did I make stupid mistakes?") The solution is to study hard and make an effort, and students believe that this will lead to the hoped success ("I'll see what mistakes I made and I'll learn from them for the next time"). The reason given as a factor for giving up on studying is a conflict with other extra-curricular areas, which prevail over studies ("I have other things to do in life besides school and I enjoy them more").

It appears that the main motivation involved in enjoyment of mathematics lessons is developing expertise ("I understood something I didn't understand before", "I succeeded in solving a problem that's considered hard"). Other motivations which contribute to enjoyment are ego - that is, the desire to demonstrate high ability or the wish to avoid demonstrating low ability ("I succeed at something other students don't").

<u>Female vs. male students</u>

On the questionnaire, it appears that achievement motivation, instrumental motivation, as well as internal motivation all affect female students more than male students. Their calibration motivation is also higher, and following failure, they are more aware than boys about the possibility of learning from mistakes, and are more willing to invest effort next time so that they succeed. In addition, they are more influenced by external motivation – they want to succeed in order to meet their parents' and teachers' demands and expectations.

<u>Differences between 7th-8th grade graduates and 9th grade graduates</u>

Ninth grade graduates showed higher motivation for developing expertise in mathematics study than did 7th and 8th grade graduates. Their calibration motivation with respect to mathematics was also higher. More than half of 9th grade graduates noted that in order to succeed effort must be invested and that they know how much effort they need to invest. In the case of failure, as compared to 7th and 8th grade graduates, 9th grade graduates are more willing to invest the effort required in the future in order to succeed. Furthermore, the attitude of 9th grade graduates to failure is more affected by comparison to their peers than is the case for 7th and 8th grade graduates.

<u>Differences between ability groupings</u>

On almost all questions, there was a noticeable difference in motivation level depending on the ability grouping the students belonged to, with students in the excellence grouping marking the greatest number of options (that is, it appears that they possess the highest motivation); their motivation level

was followed by that of students in grouping A, and so on. However, if we examine the number of respondents who study in the various groupings, we see that about half are in the excellence grouping or in grouping A. It is reasonable to assume that this distribution reflects the status in middle schools around the country, this following the Chief Inspector for Mathematics' guidance to place at least 70% of 8th and 9th grade students in groupings A and excellence[1], in the aim of expanding the number of students in 4- and 5-unit classes in high school.

[1] http://meyda.education.gov.il/files/Mazkirut_Pedagogit/matematika/mafmar_al-yesodi_tashat.docx [Hebrew]

What motivates students to invest and excel in mathematics studies? selected findings.

Motivation type	Achievement	Instrumental	External	Internal	Calibration
All Students	Aspires to succeed, high grades **(56%)**; Wishes to succeed compared to others **(38%)**	Understands that success in necessary for the future **(56%)**	Desires to meet parents' and teachers' expectations **(39%)**	Challenge, satisfaction, interest **(45%)**; Develop expertise **(55%)**	Knows success requires investment of effort **(52%)**; Knows how much effort is required to succeed **(49%)**; Ready to invest effort to succeed **(34%)**
Girls	Aspires to succeed, high grades **(63%)** ;Wishes to succeed compared to others **(44%)**	Understands that success is necessary for the future **(64%)**	Desires to meet parents' and teachers' demands and expectations **(45%)**	Challenge, satisfaction, interest **(47%)**; Develop expertise **(65%)**	Knows success requires investment of effort **(57%)**; Knows how much effort is required to succeed **(60%)**; Ready to invest effort to succeed **(35%)**
Boys	Aspires to succeed, high grades **(49%)** ;Wishes to succeed compared to others **(32%)**	Understands that success in necessary for the future **(49%)**	Desires to meet parents' and teachers' demands and expectations **(34%)**	Challenge, satisfaction, interest **(38%)**; Develop expertise **(46%)**	Knows success requires investment of effort **(43%)**; Knows how much effort is required to succeed **(40%);** Ready to invest effort to succeed **(33%)**

7th-8th grade students				Develop expertise **(52%)**	Knows success requires investment of effort **(46%)**; Knows how much effort is required to succeed **(46%)**; Ready to invest effort to succeed **(32%)**
9th grade students				Develop expertise **(62%)**	Knows success requires investment of effort **(58%)**; Knows how much effort is required to succeed **(58%)**; Ready to invest effort to succeed **(39%)**

Main insights – Science

Similar to mathematics, investment in studying science is motivated by the aspiration for tangible success, the understanding that science can be helpful in life, and involves both external and internal motivation. At the same time, it is important to note that the percentage of students who selected these statements with reference to mathematics study is higher than for science study. The enjoyment in studying science involves diverse motivations: developing expertise ("We learn something interesting", "We learn about topics that can be helpful to us in life"), in contrast to avoiding difficulty ("We prepare assignments when the material is easy and clear", "We enjoy the lesson when the material is easy and there is no homework"); but interest and the teacher's praise were also found to influence enjoyment.

As distinct from mathematics, the attribution of failure is usually internal, as students tend to admit to disappointment and say that they expected more of themselves. Similar to mathematics, the solution is to invest effort which will lead to success.

From the findings, it emerges that more aspects of internal motivation are apparent in science study in middle school than in mathematics. Science is considered an easier and less high stakes subject than mathematics, and it is likely that this relieves pressure on the students to demonstrate success and allows them more room to express their authentic feelings and tendencies.

Female vs. male students

Similar to mathematics, it appears that achievement motivation plays a more important role in the study of science for female students than for male students. Faced with failure, female students tend to attribute it to internal causes and are more likely to express their disappointment. It appears that their calibration motivation is higher, they know that in order to succeed effort must be invested, and in the case of failure, they are more willing to invest effort in the future so that they succeed.

Female students mentioned diverse and occasionally contradictory motivations as having influence on their investment in science: in parallel to external motivation (the desire to be well thought of by teachers), they reported that they are influenced by the internal motivation associated with the challenge, derive satisfaction and interest in the lesson to a greater degree than male students, but their reported desire to avoid work was much more pronounced than for boys.

Differences between 7th-8th grade graduates and 9th grade graduates

Ninth grade graduates demonstrated higher instrumental motivation than 7th and 8th grade graduates. It appears that about half of the students believe that certain science topics can be useful to them in the future. There is also evidence that calibration motivation for studying science is higher for 9th grade graduates as compared to 7th and 8th grade graduates. In contrast to mathematics study however, in the case of failure, 9th grade graduates are actually less willing than 7th and 8th grade graduates to invest effort in future success. This finding is consistent with the students' responses regarding avoiding difficulty. It appears that 9th grade students invest more in science assignments when the topic is clear to them and they know what to do, and they enjoy the science lessons when the material is easy and they do not need to make an effort or when they do not receive homework.

Motivation to choose physics as a major in high school

The picture that emerges with respect to the motivation to study advanced physics in high school is instrumental and weaker than the picture for the motivation to study mathematics and science in middle school.

About 40% of the respondents declared that they do not want to study advanced physics. Those who do want to study advanced physics in high school want to do so because it will be helpful to them in the future ("It will help me be accepted to what I want to study in university"). Those who do not want to study the field gave reasons of lack of interest ("It doesn't interest me, I don't like physics").

It is important to mention that these attitudes are based on lack of knowledge, in most middle schools, physics is not taught as a separate subject but as part of the general subject of science. Before the transition to high school, there are occasionally demonstration lessons given, designed to help students choose advanced subjects, so it is possible that their knowledge of the subject is based on a single demonstration lesson (if any).

What motivates students to invest and excel in science studies? selected findings.

Motivation type	Achievement	Instrumental	External	Internal	Calibration

All students	Aspires to succeed, high grades **(51%)**	Can be helpful in life **(40%)**	Desires to be thought well of by teachers **(32%)**	Satisfaction, interest **(45%)** Develop expertise **(38%)**	Knows success requires investment of effort **(34%)**
Girls	Aspires to succeed, high grades **(63%)**	Can be helpful in life **(44%)**	Desires to be thought well of by teachers **(36%)**	Satisfaction, interest **(49%)** Develop expertise **(42%)**	Knows success requires investment of effort **(44%)**
Boys	Aspires to succeed, high grades **(40%)**	Can be helpful in life **(35%)**	Desires to be thought well of by teachers **(29%)**	Satisfaction, interest **(41%)**; Develop expertise **(34%)**	Knows success requires investment of effort **(26%)**
7th-8th grade students		Can be helpful in life **(37%)**			Knows success requires investment of effort **(32%)**
9th grade students		Can be helpful in life **(44%)**			Knows success requires investment of effort **(39%)**