Low-Performing STEM students in Croatian primary schools: The possible gains of JOBSTEM project in improving students STEM performance

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JOBSTEM PROJECT: STEM career aspirations during primary schooling: A cohort-sequential longitudinal study of relations between achievement, self-competence beliefs, and career interests

Brings together researchers from:

- **Croatia**
  - Institute of Social Sciences Ivo Pilar
  - University of Split, Faculty of Philosophy
  - University of Zagreb, Faculty of Electrical Engineering and Computing
  - University of Zagreb, Faculty of Teacher Education

- **France**
  - Université de Poitiers

- **Hungary**
  - Central European University

- **United States**
  - University of California Irvine
The JOBSTEM project: Three main research goals

1. To examine how students’ general and specific STEM career aspirations form and how they change over time

2. To examine how students’ school achievement and self-competence beliefs relate to students’ general and specific STEM vocational preferences and the dynamics of these relations during primary school

3. To examine how students’ general and specific STEM career aspirations are shaped by their families and gender
The longitudinal-sequential design of the study with a two-group pre- and post-test randomized experiment
Participants

- Three cohorts of primary school students in three waves during three consecutive years
This study - Background

- Achievement in STEM school subjects in primary school determines high school opportunities and choices. High school choice further influences access to postsecondary and professional opportunities in STEM fields.

- However, research in STEM achievement has generally focused on the high school years (Singh, Granville, & Dika, 2002).

- Furthermore, historically, research has focused on cognitive factors as determinants of STEM learning and achievement. However, IQ accounts for about 25% of the variance in school achievement (Lau & Roeser, 2002). → Other factors are important!

- Social-cognitive models of achievement motivation emphasize beliefs, achievement values, goals, and interests as major influences on person’s achievement (Wigfield & Cambria, 2010).
This study - Background

- **Self-concept of ability and value** are constructs that are connected to various motivational theories. Empirical findings confirm these constructs are important predictors of participation and performance in different domains (Simpkins, Fredricks, & Eccles, 2014).

- Furthermore, **interest** in academic domains is particularly important for long-term outcomes such as educational and career choices (Hulleman & Harackiewicz, 2009).

- Children’s everyday activities also play a role in explaining differences in STEM achievement. Research have shown that **STEM out-of-school activities** are positively associated with children’s interest in science and self-concept of abilities in these domains (Dickhauser & Stiensmeier-Pelster, 2002).

*Research questions:* How low-STEM performing primary school students differ from high-performing students in relation to various motivational and behavioral factors? Do these differences emerge across the entire STEM school domain?
Methods
Respondents

• 1920 primary school students (age 10 – 12; 4th to 6th grade), from 16 primary schools in Zagreb and its surroundings participated in the study
• Equally represented by gender and grade

Assessment

• Paper and pencil method
• Group assessment, in the classes during the regular school activities
• Data collection lasted 45 minutes
Measures

In the Croatian school system and school curriculum the STEM area is covered by the following school subjects, depending on the grade:

- Mathematics
- Nature
- Informatics
- Technical education
- Geography
- Biology
- Chemistry
- Physics

Subjects taught in participants’ grades
Measures

- **STEM achievement**
  Total score on the objective integrated STEM achievement test (TR = 0 - 20)

- **Self-concept of ability in STEM**
  e.g.: “How good are you at math? ”/1=not very good, 7=very good/

- **Importance value of STEM school subjects**
  - *Attainment component* e.g.: „Compared to other activities, how important is it to you to be good at math?”/1 = unimportant, 7 = important)/
  - *Utility component* e.g.: „How useful is what you learn in nature?”/ 1 = not useful as the things I learn in other subjects, 7 = much more useful than the things I learn in other subjects/
Measures

▪ **Interest in STEM school subjects**
  
  e.g.: „How interesting do you find informatics?” /1 = I don't find it interesting at all, 5 = I find it very interesting/

▪ **Interest in STEM professional careers**
  
  e.g.: „How much would you like to work as a biologist?” /1 = I wouldn’t like it at all, 5 = I would like it very much/

▪ **Participation in STEM-related activities**
  
  e.g.: „How often do you read a book or magazine about science?”/ 1 = almost never, 5 = very often/

→ Items are derived from Jacqueline Eccles headed longitudinal “The Childhood And Beyond (CAB)” research project, and from the ASPIRES research project (DeWitt et al., 2013)
Results
Results

**Objective test of STEM achievement**

→ The distribution of test scores in all three tests were nearly normal; the distributions indicate good discriminating power of all three tests.
Results

*Objective test of STEM achievement - Comparison groups*

- Students’ test scores were transformed into z-values, centered around corresponding grade mean
- Z-scores for 4th, 5th, and 6th graders were combined into a single scale
- Students who scored $z > 1$ ($N = 319$) and $z < -1$ ($N = 272$) were selected for comparisons to create a clear distinction between the groups and increase the chances of finding meaningful differences
Results

Differences between high and low-achievers

Gender

\[ \chi^2 = 7.58; \ df = 1; \ p < 0.01 \]

Phi value (\(\Phi\)) = .12

→ small effect size
Results

Self-concept of ability in STEM domains

e.g. „Compared to other subjects how good are you at _____?“

**Table 1**
Univariate results from MANOVA comparing self-concept of ability in STEM domain

<table>
<thead>
<tr>
<th></th>
<th>Low achieving</th>
<th>High achieving</th>
<th>F</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Math</td>
<td>3.69</td>
<td>1.04</td>
<td>5.74</td>
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<td>Nature</td>
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<td>1.21</td>
<td>5.48</td>
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<td>Geography</td>
<td>4.06</td>
<td>1.23</td>
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<td>1.14</td>
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<td>Technical education</td>
<td>5.17</td>
<td>1.26</td>
<td>5.47</td>
<td>1.18</td>
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<tr>
<td>Informatics</td>
<td>5.55</td>
<td>1.28</td>
<td>6.04</td>
<td>1.05</td>
</tr>
</tbody>
</table>

**p < .001**

*large effect size*
Results

Importance value of STEM domains

e.g. „Compared to other subjects how useful is _____?“

Table 1

Univariate results from MANOVA comparing importance value of STEM domains

<table>
<thead>
<tr>
<th></th>
<th>Low achieving</th>
<th>High achieving</th>
<th>F</th>
<th>d</th>
<th>medium effect size</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>5.19</td>
<td>1.08</td>
<td>5.76</td>
<td>1.00</td>
<td>21.31**</td>
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<td>4.89</td>
<td>1.21</td>
<td>4.73</td>
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<td>5.15</td>
<td>0.99</td>
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<tr>
<td>Technical</td>
<td>4.49</td>
<td>1.38</td>
<td>4.30</td>
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<td>education</td>
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<tr>
<td>Informatics</td>
<td>5.36</td>
<td>1.27</td>
<td>5.57</td>
<td>1.10</td>
<td>2.07</td>
</tr>
</tbody>
</table>

** p < .001
Results

Interest in STEM school subjects

e.g. “How interesting do you find _____?”

Table 2
Univariate results from MANOVA comparing interests in STEM school subjects

<table>
<thead>
<tr>
<th></th>
<th>Low achieving</th>
<th>High achieving</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>SD</td>
<td>M</td>
<td>SD</td>
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<td>Math</td>
<td>3.19</td>
<td>1.04</td>
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<tr>
<td>Nature</td>
<td>3.91</td>
<td>1.00</td>
<td>3.73</td>
<td>1.17</td>
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<tr>
<td>Geography</td>
<td>3.46</td>
<td>1.27</td>
<td>3.88</td>
<td>1.10</td>
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<tr>
<td>Technical education</td>
<td>3.66</td>
<td>1.32</td>
<td>3.14</td>
<td>1.24</td>
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<tr>
<td>Informatics</td>
<td>4.28</td>
<td>1.08</td>
<td>4.28</td>
<td>0.98</td>
</tr>
</tbody>
</table>

**p < .001; * p < 0.1

Unexpected result
Results

Interest in STEM professional careers

e.g. „How much would you like to work as a physicist?“

Table 4
Univariate results comparing interests in STEM professional careers

<table>
<thead>
<tr>
<th></th>
<th>Low achieving</th>
<th>High achieving</th>
<th>t</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>2.15</td>
<td>2.75</td>
<td>-8.36**</td>
<td>0.72</td>
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<tr>
<td>SD</td>
<td>0.79</td>
<td>0.87</td>
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</tbody>
</table>

** p < .001

medium to large effect size
Results

Participation in STEM-related activities

e.g. „How often in your spare time do you do science activities - e.g., science kits, nature walks, do experiments?„

Table 3
Univariate results comparing participation in STEM-related activities

<table>
<thead>
<tr>
<th></th>
<th>Low achieving</th>
<th>High achieving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>M</td>
<td>2.44</td>
<td>2.77</td>
</tr>
<tr>
<td>SD</td>
<td>0.77</td>
<td>0.81</td>
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</table>

**small to medium effect size**

**p < .001**
Summarized Findings

• Results indicate that when using objective STEM test as a measure of STEM achievement, girls perform slightly lower than boys.

• In comparison with the high-achievers, students in the low-achieving group:
  • had lower self-concept of ability in math, nature, geography, and informatics
  • perceived lower importance value for math
  • expressed lower interest for math and geography, but higher interest for technical education
  • showed lower interest in STEM professions
  • reported to participate less often in STEM out-of-school activities

• The largest differences were recorded in students’ self-concept of ability in STEM subjects and students’ interests in STEM professional careers.
Discussion and Implications

• Differences in self-concept of ability in low and high-achievement groups are not consistent across STEM area → this confirms the multidimensionality of academic self-concept

• Low achieving students differ the most from the high achieving in the math self-concept → Special attention in the classroom should be given to fostering low achieving students competence beliefs in math tasks

• Interestingly, low achieving students perceive lower importance value only for math, but not for the other STEM subjects → Low achieving students need external support in perceiving relevance, usefulness and value in their math schoolwork. This may also lead to the improvement in their interest in math, since studies have shown that perceiving a topic to be useful and relevant predicts subsequent interest in a course (Hulleman, Durik, Schweigert, & Harackiewicz, 2008)
Discussion and Implications

• Unexpected higher interest in technical education in low-achievers can be seen as an opportunity for the educators to motivate even less achieving students to pursue careers in technical professions of the STEM domain.

• Quite large difference in the interest for STEM careers can in school context be addressed through increasing the attractiveness of STEM professions among lower achieving students, namely by building on the disciplines in which lower groups do not lack interest, i.e. ICT & technical domain.

• Low-achieving students participate less in STEM-related out-of-school activities. Fostering this involvement, especially in younger cohorts, can present a potential avenue for parents and educators to increase later choices in STEM domain, since longitudinal research confirmed the links between early STEM involvement – positive STEM-related beliefs – and consequently STEM choices (Simpkins, Davis-Kean, & Eccles, 2006).
Thank you!

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Literature


