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TIMSS 2011: Relationship between Self-Confidence and Cognitive Achievement for Serbia and Slovenia¹

TIMSS 2011: La relación entre la autoconfianza y el logro cognitivo en Serbia y Eslovenia

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Abstract

By using TIMSS Grade 4 2011 science data for Serbia and Slovenia, this study examined which of two dimensions of science learning (self-confidence in science learning, or liking science learning), if any, was primarily related to students' cognitive achievement in science. This achievement was considered for three cognitive domains, namely: knowing, applying, and reasoning. The analysis revealed that in both countries achievement was mainly linked to self-confidence in each of the three cognitive domains. Because of positive correlations, classroom work may be improved by including, whenever possible, activities aimed at strengthening students' belief in their own ability to learn science.

Keywords: Cognitive achievement, Fourth grade, Self-confidence, TIMSS.

Resumen

Mediante los datos científicos del TIMSS Grado 4º 2011 para Serbia y Slovenia, este trabajo examina cuál de las dos dimensiones del aprendizaje científico (auto-confianza en el aprendizaje científico o el gusto por el aprendizaje científico) se relaciona con el desempeño cognitivo de estudiantes de ciencia. Este desempeño se contempla para tres dominios cognitivos, a saber: conocer, aplicar y razonar. El análisis muestra que en ambos países el desempeño está vinculado principalmente con la auto-confianza en cada uno de los tres dominios cognitivos. Debido a las

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correlaciones positivas, el trabajo en el aula puede mejorarse mediante la inclusión, siempre que sea posible, de actividades encaminadas al fortalecimiento de la confianza de los estudiantes en sus propias habilidades para adquirir el conocimiento científico.

Palabras clave: Logro cognitivo, cuarto grado, auto-confianza, TIMSS.

I. Introduction

TIMSS is a widely-known project of the International Association for the Evaluation of Educational Achievement. It is one of the largest international comparative education studies. Since 1995, the TIMSS research has been carried out in four-year cycles, and TIMSS 2011 belongs to the fifth cycle (see <http://timssandpirls.bc.edu/>). In Serbia, this kind of study has been conducted since 2003. The third and fourth cycles were carried out with eighth-grade students, whereas the fifth cycle in 2011 included fourth-grade students for the first time. A total of 4,379 students were tested from 219 classes in 156 primary schools. Contrary to the science outcomes in TIMSS 2007, the TIMSS 2011 results in science were very encouraging because Serbia's fourth-grade students achieved 516 points, which was significantly higher than the TIMSS scale average (Martin, Mullis, and Foy, 2008; Martin, Mullis, Foy, and Stanco, 2012). The cognitive achievements of Serbian students in 2011 were also very good. These achievements –determined by using three variables for cognitive domains regarding knowledge, application, and reasoning– were better than the overall average results of all the countries that participated in the testing (see Table 1). It can thus be said that, in general, primary school teachers in Serbia have done their job well for the content of science courses. However, the categorization of TIMSS test items is just based on an acceptable approximation, which means that the ranking of nations should not be viewed in an absolute but rather an approximate sense (Nixon and Barth, 2014).

Table I. Average science achievements by country

Country	Number of Tested Students	Overall Achievement	Achievement by Cognitive Domain		
			Knowledge	Applying	Reasoning
Serbia	4,379	516	524	506	519
Slovenia	4,492	520	518	518	525

Let us first focus on three TIMSS cognitive domains. They can be described as follows: “Knowing covers the student’s knowledge of science facts, procedures, and concepts. *Applying* focuses on the student’s ability to apply knowledge and conceptual understanding in a science problem situation. *Reasoning* goes beyond the solution of routine science problems to encompass unfamiliar situations, complex contexts, and multi-step problems.” (Martin et al., 2012, p. 142). Although these domains were not based upon an elaborate theoretical framework, it is relatively easy to recognize that they are related to cognitive domains found in the well-known Bloom’s taxonomy. Bearing in mind their definitions below, it is clear that Knowing and Applying include Bloom’s Knowledge, Comprehension, and Application levels, whereas Reasoning is based on Bloom’s Analysis, Evaluation and Synthesis levels (Gutvajn, Džinović, and Pavlović, 2011).

Let us now move to TIMSS contextual variables that have been found to be related to TIMSS achievement in general. They are, for example, self-confidence in learning a subject, and liking the subject, which are both positively related to achievement (e.g., Martin et al., 2012; Mullis, Martin, Foy, and Arora, 2012). In the context of science, these TIMSS variables (i.e. the constructs underlying them) may be briefly defined as follows.

- *Self-confidence in learning science* involves student’s positive/negative beliefs about his/her ability to learn science with respect to himself/herself, other students, and the teacher.

- *Liking to learn science* refers to the degree of enjoyment in learning scientific content, studying them in the student's free time, and the perception of science as an interesting field.

Although an elaborate theoretical framework is also missing here, it is clear that these two constructs are important dimensions of student attitude towards science learning (cf. Kadijevich, 2008).

Let us finally return to the cognitive achievements for Serbian students. Bearing in mind that self-confidence and liking learning are both positively related to achievement, we focused on the question of which is more highly correlated to cognitive achievements. Furthermore, we were interested in comparing the answer to this question for Serbia to the answer for Slovenia. (Slovenia is one of the countries in the region where students traditionally have good TIMSS results in science (Martin et al., 2008, 2012); the average overall achievements in 2007 and 2011 were 518 and 520, respectively). Although achievement and any such dominant variable are probably mutually dependent (i.e. their relationship is bidirectional), it is reasonable to assume that investing in this variable would result in better achievement.

II. Design and variables

This study applied a correlative design. It used six variables described below.

- **Achievement** measured the student's overall science achievement. For each student, the mean value of five plausible values provided in the official data file was used. The reliability of this measure (Cronbach's alpha), based on these five values, was 0.95 for Serbia and 0.96 for Slovenia.
- **Knowing** measured the student's achievement in science with regards to the cognitive domain 'Knowing'. For each student, the mean value of five plausible values provided in the official data file was used. The reliability of this measure, based on these five values, was 0.95 for Serbia and 0.96 for Slovenia.
- **Applying** measured the student's achievement in science with regards to the cognitive domain 'Applying'. For each student, the mean value of five plausible values provided in the official data file was used. The reliability of this measure, based on these five values, was 0.96 for Serbia and 0.95 for Slovenia.
- **Reasoning** measured the student's achievement in science with regards to the cognitive domain 'Reasoning'. For each student, the mean value of five plausible values provided in the official data file was used. The reliability of this measure, based on these five values, was 0.95 for Serbia and 0.94 for Slovenia.
- **Self-confidence** measured the student's self-confidence in learning science. For each student, the mean value of his or her responses to six statements given in Display 1 was used (the TIMSS official scoring of 1-4 for "Agree a lot" – "Disagree a lot" was reversed for statements *a*, *d* and *e*). The reliability of this measure, based on answers to these six statements converted into numbers, was 0.82 for Serbia and 0.83 for Slovenia.

MS6

How much do you agree with these statements about science?

Fill one circle for each line.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
a) I usually do well in science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) Science is harder for me than for many of my classmates ----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) I am just not good at science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) I learn things quickly in science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) My teacher tells me I am good at science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f) Science is harder for me than any other subject -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Source: http://timss.bc.edu/timss2011/downloads/T11_StuQ_4.pdf (p. 14)

Figure 1. Statements regarding self-confidence in learning science

- **Liking** measured the student's liking of science and of learning science. For each student, the mean value of his or her responses to six statements given in Display 2 was used (the TIMSS official 1–4 scoring for “Agree a lot”– “Disagree a lot” was reversed for statements a, c, e and f). The reliability of this measure, based on answers to these six statements converted into numbers, was 0.86 for Serbia and 0.87 for Slovenia.

MS4

How much do you agree with these statements about learning science?

Fill one circle for each line.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
a) I enjoy learning science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) I wish I did not have to study science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) I read about science in my spare time -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) Science is boring -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) I learn many interesting things in science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f) I like science -----	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Source: http://timss.bc.edu/timss2011/downloads/T11_StuQ_4.pdf (p. 12)

Figure 2. Statements regarding liking science

Notes:

1. The study included only students who had values for all six variables. There were 4,050 such students in Serbia and 4,164 in Slovenia (92% and 93% of all students involved in the TIMSS study in these countries, respectively).

2. The Cronbach's alpha reliabilities were determined for weighted data. The weights were calculated in the following way:
 $wgt_serbia = totwgt * 4050 / 59204.93$, and
 $wgt_slovenia = totwgt * 4164 / 16100.96$
 (totwgt is the student's weight provided in the official files, whereas 59,204.93 and 16,100.96 are sums of these students' weights).

III. Results

Table II reports the means of the measured variables by country. Serbian and Slovenian students did not differ much with regards to the two attitudinal dimensions measured, especially Self-confidence (3.3 vs. 3.2).

Table II. Means of the measured variables by country

Country	Number of Tested Students	Overall Achievement	Achievement by Cognitive Domain			Self-confidence	Liking
			Knowledge	Applying	Reasoning		
Serbia	4,050	519	527	510	523	3.3	3.3
Slovenia	4,164	522	520	520	527	3.2	3.1

The correlations between Self-confidence and Liking on the one hand, and the four attainment variables on the other hand, are presented in Table 3. Although almost all correlations regarding Liking were significant, they could explain less than 1% of the variation in each attainment variable (e.g., $0.071^2 * 100\% = 0.5\%$). The extent of this explanation for Self-confidence was between 9% ($0.295^2 * 100\%$) and 16% ($0.395^2 * 100\%$).

Table III. Correlations and their significance

Attainment variable Affective variable/Country	Achievement	Achievement by Cognitive Domain		
		Knowing	Applying	Reasoning
Self-confidence				
Serbia	0.312**	0.319**	0.295**	0.324**
Slovenia	0.374**	0.395**	0.371**	0.346**
Liking				
Serbia	0.043*	0.049*	0.044*	0.071**
Slovenia	0.033+	0.054**	0.010	0.035+

The weighted data were analyzed + $p < 0.05$ * $p < 0.01$ ** $p < 0.001$

IV. Discussion

To recall the question used in this study, it was found that, in both Serbia and Slovenia, cognitive achievement was primarily linked to self-confidence. As expected, this relationship was positive, and for Achievement (i.e. overall achievement), Knowing and Applying, stronger in Slovenia than in Serbia (0.374 vs. 0.312; $Z = 3.184$, $p = 0.0015$). However, the two variables (Self-confidence and each of the achievement variables) did have a modest common variation. The dominance of the relationship between self-confidence and overall achievement was also found in Kadijevich (2008) for example, albeit for mathematics.

As already mentioned in the introduction, although self-confidence and achievement are probably mutually dependent, it is reasonable to assume that investing in self-confidence would result in better achievement. This can be achieved by a variety of techniques to boost self-confidence – for example, through discussions about one's own gains in learning science, such as

what knowledge and skills students have mastered with ease, and the content they enjoyed learning. Students with low self-confidence in learning science should be helped with approaches to learning that elicit their initiative, encourage and scaffold their problem solving, and encourage them to state their opinions. Perhaps the most important thing is to create a respectful and encouraging atmosphere in the classroom where students support each other and want to talk openly about their experience rather than just passively receive ready-made knowledge and skills. Furthermore, negative emotional responses should be avoided in learning activities because emotional responses have considerable influence on the development of self-concept (Mujtaba, Reiss, and Hodgson, 2014). Because of that, activities for strengthening self-concept should mainly generate positive emotional responses (compare "Look, I can complete this task!" with "I am again unsuccessful at problem solving!"). Finally, when designing activities to strengthen self-confidence, the teacher should bear in mind that "a strong self-concept encourages students to engage with the instruction and show persistence, effort, and attentiveness." (Martin et al., 2012; p. 331)

To conclude, the results for Serbia and Slovenia show that self-confidence may be a major dimension of attitude when the relationship between this confidence and achievement is in focus. Further research may examine whether this pattern applies to a larger group of countries when science learning is in question. Because this relationship is positive, it is very likely that, in general, developing students' self-confidence in a (more) positive direction would improve his or her achievement. However, as the relationship between the two is bidirectional, further research may focus on uncovering, to some extent, the nature of the relationship between self-confidence in learning science and science achievement (how one influences the other), which can then be used as a basis for designing successful ways of using one to improve the other.

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