TRAMES, 2010, **14**(**64/59**), 3, 271–281

ARE THE LINKS BETWEEN ACADEMIC ACHIEVEMENT AND LEARNING MOTIVATION SIMILAR IN FIVE NEIGHBOURING COUNTRIES?

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Abstract. The model for relationships between general educational performance (GEP) and non-cognitive characteristics (e.g. students' self-evaluation and motivation in science), was worked out previously on Estonian data (Täht and Must 2009). The aim of this paper was to fit the model on the data of four neighbouring countries. The analyses showed that Estonian model fits the Finnish, Latvian, Russian and Swedish data. Students' self-evaluation in science (SE) has a relatively strong and stable relationship (.55–.64) with their GEP in all five countries. Students' science learning motivation (SM) has moderate or even no relationship with their general educational performance (.05–.42). Five neighbouring countries are ordered by the size of the last relationship as follows: Russia, Latvia, Estonia, Sweden and Finland. These variations may result from differences in cultural influences on personality or from national educational and social policies. The differences have developed during the course of history, cultural and political development.

Keywords: abilities, non-cognitive characteristics, educational achievements, PISA, Estonia, Finland, Latvia, Sweden, Russia

DOI: 10.3176/tr.2010.3.04

1. Introduction

Recently, much psychological research has been carried out to find universal phenomena across nations, for example in the structure of personality (McCrae et al. 1996), in self-esteem (Schmitt and Allik 2005), in beliefs and values (Inglehart 2006), in the link between IQ and wealth (Lynn and Vanhanen 2002, 2006). This research is valuable for testing different psychological theories in different cultural contexts.

The links between educational achievement and non-cognitive characteristics (such as interest in learning and self-evaluation) have been research objects for a long time: reports have been written analyzing the reciprocality of attitudinal characteristics (e. g. self-concept, self-efficacy, attribution, motivation, interests, and learning strategies) and the results of achievement tests (DiPerna et al. 2005, Schunk 1991, 2003, Multon et al. 1991). The focus of this research is on the relationship between the academic achievement and students' non-cognitive characteristics. F. Gagnè and F. St. Père had questioned with their work (2001) the common belief of most educators about the crucial role of motivation as a determinant of scholastic achievement, since they did not find clear empirical support for hypothesis that motivation contributes to the educational results (a study carried out among Canadian students).

The international educational studies conducted in the last few decades, such as PISA (Programme for International Student Assessment) and TIMSS (Third International Mathematics and Science Study), have established conditions for researching educational achievement together with students' non-cognitive characteristics based on vast data banks. Reports about this interaction on the individual level considering international students' tests like PISA and TIMSS are have been? written (Täht and Must 2009, Eklöf 2007, Shen and Pedulla 2000), and there are some attempts to compare this interaction between different countries (Shen and Pedulla 2000). In these reports, positive correlations are shown between motivation and achievement and also between self-evaluations and achievement on the individual level.

The question of whether the links between students' achievement and non-cognitive characteristics are universal across different countries is not answered. The research on IQ and its correlates is an excellent example of how these data can be put to use. For example, Rindermann (2007) has showed the possibility to use a country's results in international tests like PISA or TIMSS as that country's IQ indicator. The same theme has been under consideration in the studies of Weiss (2008) and Lynn and Mikk (2009). The challenge is to seek similarity across nations in the data collected by the same methodology. There are first attempts to investigate the relationship between educational achievement and attitudes on the basis of data of international educational surveys across nations (Ross and Victoria 2009, Chiu and Xihua 2008, Shen and Pedulla 2000). The aim of this paper is to continue in this vein – to estimate the generalizability of the relationship of educational achievement and attitudes in five neighbouring Baltic and Nordic countries. According to Lynn and Vanhanen (2006:54) neighbouring countries have closely similar IQs. The achievement test results are only part of the data collected by these international tests, in PISA 2006 research data, the answers to non-cognitive questions are given, too.

In the above-mentioned paper (Täht and Must 2009), the relationships between general educational performance (GEP) and attitudes towards science learning were analysed using the Estonian PISA 2006 sample. The variable GEP was modelled as a common latent variable of the three observed achievement scales (mathematics, reading and science). Of thirteen attitudinal PISA scales, eight were used, related to student selves, not to general themes such as the environment. There were two latent attitudinal variables behind the eight self-related attitudinal scales: science learning motivation (SM) and self-evaluation (SE). Both variables correlated with GEP: r = .20 and r = .60, respectively. All three PISA achievement scales and most of the attitudinal indicators form a clear and parsimonious model (Figure 1).

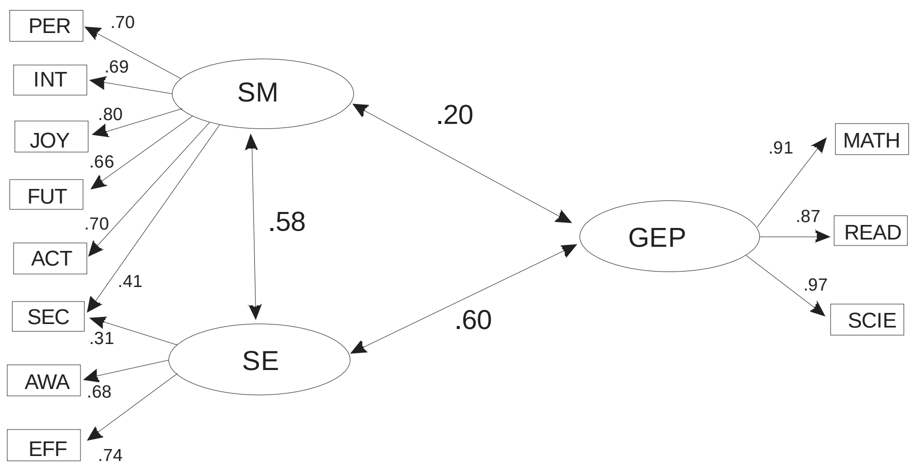

Figure 1. The model of the relationship between attitudinal factors (SM, SE) and general educational performance (GEP) from the Estonian data (AA model).
Notes. Fit indices of the model: RMSEA = .055, SRMR = .04, CFI = .99. The abbreviations are given in the table 1.

Motivation, interests, self-evaluation are constructs related to culture and the development of a country. It is highly plausible that the links between ability and attitudes vary in different countries. On the level of international educational surveys, there is the potential of establishing which links are universal and which apply only in certain conditions.

As a step in searching for similarities in the relations between general educational performance and attitudes, the Estonian model worked out before (Figure 1) is examined by means of a variance analysis on the neighbouring countries' data: Finland, Latvia, Russia and Sweden. The similarity of neighbouring countries is a hypothesis used also by other researchers like Lynn and Vanhanen (2002).

2. Method

Samples. The general PISA 2006 sample consists of around 400,000 students representing about 20 million 15-year-olds at the schools of 57 participating countries. The average age of the sample group was 15.8 years, and the sample was approximately equally divided by gender. We used the model developed previously (Täht and Must 2009) on the basis of the Estonian data (n = 4739) for comparison with data from the Finnish (n = 4545), Swedish (n = 4110), Latvian (n = 4584) and Russian (n = 5539) samples.

Measures. Educational achievement tests were implemented in mathematics, reading and science. PISA students' achievement dataset provides the so-called plausible values for secondary analysis. Plausible values are multiple imputations of unobservable latent achievement for each student (Wu 2005). There were five plausible values for all three subjects within the framework of the PISA 2006 (OECD 2006). We used the first of the plausible values of each subject (Wu 2005) for analysis.

Besides answering the achievement test items, participants were also asked to answer a Student Questionnaire containing questions about various topics including their learning motivation towards science and beliefs about academic self-efficacy (OECD 2007). Each non-cognitive question required students to express their level of agreement on a four-point scale with two or three statements expressing either interest in science or support for science. Non-cognitive indices in the PISA data-set had been formed by using item response theory methods (OECD 2007). Each index is based on 4–7 questions.

Non-cognitive indices in the PISA 2006 framework are divided into four sections: motivational factors, science self-beliefs, value beliefs regarding science and scientific literacy and environment. There were deviations from normality in the distribution of some attitudinal indices in country-level data. The non-cognitive PISA 2006 measures used in the current analysis are the following: general interest in science (INT), enjoyment of science (JOY), future-oriented motivation to science (FUT), self-efficacy in science (EFF), self-concept in science (SEC), science activities (ACT), personal value of science (PER), awareness of environmental issues (AWA). The indices mentioned above were related to student selves, not to general themes such as the environment.

Descriptive statistics of attitudinal indices and achievement test scores are presented in Table 1.

Table 1. The description of non-cognitive indices and achievement test scores of PISA 2006 in five countries (ordered by average achievement score).

	FIN		EST		SWE		LVA		RUS	
	Avg.	St. dev.	Avg.	St. dev.	Avg.	St. dev.	Avg.	St. dev.	Avg.	St. dev.
MATH	550.72	79.88	518.3	78.99	507.79	86.86	492.53	80.01	480.74	88.62
READ	548.36	80.03	504.92	82.1	514.69	93.28	486.94	88.37	444.89	91.93
SCIE	565.02	85.11	535.25	82.88	509.912	90.84	495.46	82.36	483.21	89.15
INT	–0.21	.94	.19	.74	–.09	1.02	0.16	.67	.27	.73
JOY	.12	.89	.01	.85	–.08	1.03	–0.01	.69	.11	.78
FUT	–.17	.86	–.08	.85	–.21	.96	–.09	.81	.31	0.78
EFF	.03	.92	.04	.85	–.03	.99	–.002	.82	–.004	.98
SEC	.07	.85	.11	.80	.02	1.03	.02	.70	.16	.73
PER	.15	.84	.15	.84	–.09	1	.13	.78	.14	.84
ACT	.39	0.8	.39	.8	–.38	.95	.25	.80	.55	.79
AWA	.25	0.92	.25	.92	–.21	1.1	–.004	.83	.20	.94

Initial model. The previous analysis showed (Täht and Must 2009) that the meaningful and acceptable model has 3 latent factors. On the cognitive side of the model, there were three observed PISA 2006 achievement scales (MATH, READ and SCIE) which can be reduced to one latent variable- general educational performance (GEP). There are two non-cognitive latent factors – learning motivation toward science (SM) and self-evaluation (SE) (Figure 1). SM has a latent impact on the observed indices JOY (*enjoyment of science*), PER (*personal value of science*), INT (*general interest in science*), FUT (*future-oriented motivation to science*), SEC (*self-concept in science*) and ACT (*science activities*). The second latent non-cognitive factor SE is based on three indices: EFF (self-efficacy in science), SEC (self-concept in science) and AWA (awareness of environmental issues). The inclusion of the index AWA was not so evident and needs the analysis of the content of the test items. Children had to choose between the answers that indexed their agreeing with the statements *I have heard about it and I can explain it* or *I know something about this and could explain the general issue*. This means that the index is not only about the awareness of environmental issues, but rather about the self-evaluation about one's awareness. The structural model obtained in previous work (Täht and Must 2009) shows that the variable GEP is related both to the student's self-evaluation in science with a correlation of .60 and to the learning motivation (interest in and enjoyment of science learning) with correlation .20. These two attitudinal factors correlated at r = .58 on Estonian data (Figure 1). The purpose of this work is to establish whether the structural relationships found on Estonian data are similar with the data of the neighbouring countries.

Models. In this study, we examined four hypothetical models (one for each country) that all contained eight observed and two latent attitudinal variables, as well as three observed and one latent achievement variable. All three latent variables were assumed to be in reciprocal relationship with each other.

Confirmatory factor analysis (CFA). Structural modelling (SEM) was used for the estimation of the relationship between academic achievement and study attitudes in the Estonian sample. The estimation method was robust maximum likelihood due to the inclination to normal distribution in non-cognitive indices. Multiple-Group Confirmatory Factor Analysis (MGCFA) was used to investigate the model invariance in Estonia's neighbouring countries (Finland, Latvia, Russia and Sweden).

MGCFA with Lisrel 8.80 (Jöerskog and Sörbom 2006). Statistical indices used to evaluate the structural models (CFA) were: Chi-squared (χ^2) statistics, root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR) and comparative fit index (CFI). The value of χ^2 is inflated by the sample size, and large N solutions are routinely rejected on the basis of χ^2, even when differences between real data and prediction are negligible (Brown 2006). As findings suggest that for most fit indices, it would be difficult to establish cut-off criteria that would be generally useful in SEM applications (Fan and Sivo 2007), we used four different indices.

The following goodness-of-fit indices were used during the MGCFA analysis: Chi-squared, RMSEA, CFI and NNFI (Tucker Lewis index or Non-Normed fit index). As the value of χ^2 is inflated by the sample size, the absolute value of χ^2 was not the issue, but changes in the value of χ^2.

The following cut-off values for goodness-of-fit are used: for SRMR .08 or below, for RMSEA .06 or below, and for CFI and NNFI .95 or greater (Brown 2006, Hu and Bentler 1999). CFI is independent from sample sizes. For RMSEA, there are some specifications: RMSEA values less than .05 suggest a good model fit, and models with RMSEA $\geq$ .1 should be rejected, RMSEA $\leq$ .08 suggests an adequate model fit (Browne and Cudec 1993). The RMSEA requires less stringent cut-off values as the sample size increases (Sivo et al. 2006).

The following modelling steps were used to evaluate the goodness of MGCFA models (Brown 2006):

1. *Equal form* or *configural invariance* – the model is the same across the groups, but the unknown parameters of the model are assumed to be different across the groups.
2. *Equal factor loadings* or *weak factorial invariance* for a measurement implies that the model is the same across the groups and the factor loadings are identical across the groups.
3. The equality of indicator intercepts has been alternatively termed *scalar invariance* or *strong factorial invariance.*

Strong factorial invariance implies that any systematic group differences in either the means or covariances among the measured variables are due to the common factors, rather than other sources of association (Millsap and Meredith, 2007).

The multiple group analysis begins with the least restricted solution (equal form), and subsequent models are evaluated that entail increasingly restrictive constraints.

3. Results

The CFA analysis. We have used the previously obtained (Figure 1) as a hypothetical model for other countries' data for estimating its possible universality. The results of how the hypothetical model fits to the data from the five countries are in Table 2.

The analysis showed a similar goodness-of-fit of the hypothetical model to the data of all 5 countries: RMSEA was less than .063 for all countries' data (Table 2), which indicates an adequate fit. CFI was over or equal .98 and SRMR was less or equal .050 for all countries' data, which indicates a good fit to the hypothetical model of all five countries' data. Chi-squared was larger than critical, $\chi^2 > 434$ (degree of freedom: df = 40), and therefore did not indicate an adequate fit. But as the value of χ^2 is inflated by the sample size and the sample sizes were big in our investigation, this did not provide a reason for rejecting the models. Therefore there was sufficient reason to claim that the hypothetical model fits adequately to the data of all four countries: Finland, Latvia, Sweden and Russia. There were, however, some variations in the different countries' models: the correlations between the latent variables SE and GEP differed slightly (.52–.64) in the models of different countries. But there is a high fluctuation in the relationships between SM and GEP (.01–.43).

Table 2. Results of confirmatory factor analysis for the relationship between non-cognitive latent factors and general educational performance

	Fit indexes				Correlations		
Model	χ^2	RMSEA	SRMR	CFI	SM&GEP	SE&GEP	SM&SE
EST	619.98	.055	.040	.99	.20	.60	.58
FIN	612.61	.056	.028	.99	.42	.58	.67
LVA	434.97	.046	.032	.99	.10	.57	.54
RU	778.92	.058	.050	.98	.05	.55	.54
SWE	677.02	.062	.029	.99	.41	.64	.74

	Factor loadings/Residuals											
	Factor SM						Factor SE			Factor GEP		
Model	JOY	ACT	FUT	INT	PER	SEC	EFF	AWA	SEC	MATH	READ	SCIE
EST	.80/.35	.70/.51	.66/.56	.69/.52	.70/.51	.41/.59	.74/.45	.68/.54	.31/.59	.91/.16	.87/.24	.97/.05
FIN	.83/.32	.70/.52	.70/.51	.78/.40	.78/.39	.37/.49	.79/.37	.72/.48	.71/.49	.87/.24	.82/.33	.99/.02
LVA	.78/.40	.69/52	.61/.62	.66/.56	.68/.54	.44/.67	.66/.55	.67/.55	.20/.67	.86/.25	.83/.31	.98/.03
RU	.73/.46	.72/.48	.63/.60	.72/.49	.71/.50	.44/.66	.72/.48	.58/.66	.21/.66	.83/.31	.77/.40	.95/.10
SWE	.87/.24	.67/.56	.74/.45	.77/.41	.79/.37	.29/.48	.74/.45	.66/.57	.48/.48	.90/.19	.85/.27	.97/.05

* Degree of freedom (*df*) is constant for all five models (*df* = 40)

The MGCFA analysis. An advantage of MGCFA is that all potential aspects of invariance across groups can be examined (Brown 2006). The CFA analysis for five hypothetical models was successfully completed, indicating the possibility to continue with MGCFA analysis. The results of different steps of MGCFA are given in Table 3.

Table 3. Goodness-of-fit indices of the MGCFA analysis.

	df	RMSEA	SRMR	CFI	NNFI
M1. Equal form	204	.055	.05	.99	.98
M2. Equal factor loadings	240	.057	.059	.98	.98
M3. Strong invariance	292	.116	.076	.91	.92

The first step of the MGCFA was to confirm *equal form* of the groups. Goodness-of-fit indices showed a good fit to the five countries' data: RMSEA = .055, CFI = .99 and NNFI = .98. Therefore our claim that the same model fits all 5 countries' data was proved. This was the reason for perfoming the second step of MGCFA, testing *equal factor loadings* of the groups. For the second step, the goodness-of-fit indices also showed a good fit to the five countries' data: RMSEA = .057, CFI = .98 and NNFI = .98 (Table 3). Two first steps of MGCFA showed that the measures of the AA model have the same structure for different countries' data.

The *equality of indicator intercepts* was also tested, but the goodness-of-fit indices did not show an adequate fit: RMSEA = .116, CFI = .91 and NNFI = .92 (Table 3).

4. Discussion

According to Jensen, Spearman's doctoral student Webb found two different factors – a factor of mental ability and a factor formed by other personality indicators. He named the latter will or persistence of motives. The current analysis demonstrated that the old idea of the persistence of motives in interaction with educational achievement may have important consequences across nations.

The variability of different educational achievements, in science, mathematics and reading, is reducible to one latent variable – named GEP in the present study. The different non-cognitive indices (connected with student's selves, not general ones) are reducible to two latent variables: a student's self-belief regarding his/her success in science (SE) and his/her interest in science (SM). These three latent variables constitute a meaningful and statistically good model for the Estonian PISA 2006 data. The same fitted statistically all four neighbouring countries' data as well (Table 2).

From MGCFA, it was clear that all five models are invariant up to the level of factor loadings. The analysis showed that variables in the models have a similar meaning and structure. All countries considered had different achievement levels, and there were also differences in the average sizes of attitudinal indices (Table 1). The latter fact may cause difficulties in modelling an invariant relationship between attitudes and achievement.

Differences in the models. The relationships between the latent variables were the most interesting part of the research; the analysis did not show a uniform and strong relationship between SM and GEP in different models. The analysis showed that there was a bigger difference in the relationships between SM and GEP than in the relationships between SE and GEP in the models of these five countries. The relationships between SE and GEP remain rather stable in the models of different countries' data (.55–.64). These strong relationships show that in the researched countries, the students with a high self-evaluation in science mostly performed well on GEP. This principle also works the other way round: most of the students with high achievement parameters have high self-evaluation. This result is consistent with the previous metaanalysis (Robbins et al. 2004): The best predictors of grade point average were found to be self-efficacy and achievement motivation. Pullmann and Allik (2008) found that the students' academic self-evaluation was related to their academic achievement, with the mean correlation of .53.

The relationship between the two latent attitudinal variables SE and SM is also rather stable (.54–.74), which was not surprising considering the previous theory about motivation and self-efficacy. Self-beliefs of efficacy play a key role in the self-regulation of motivation (Bandura 1994:73).

There is a big cross-cultural difference in the relationships between SM and GEP (.05–.42). Five neighbouring countries are ordered by the size of the last relationship as follows: Russia, Latvia, Estonia, Sweden and Finland. This very low relationship (.05) indicates the lack of a natural positive relationship between students' learning motivation and their educational achievement. When trying to find the reasons for this fact, we must not forget that the attitudes were measured towards science. For instance, the lack of interest towards studying science among students in Estonia is a widely known fact. In the EU, the numbers of students graduating from the university specializing in MST (mathematics, science, technology) have been compared in different countries (Commission of the European Communities 2007:127). This European comparison of higher education reveals that annually, 12.1 students specializing in MST between the ages of 20 and 29 graduate in Estonia per 100,000 citizens. The European average is 13.1. In Latvia, this figure is below the average (9.8), whereas the figures for Finland (17.7) and Sweden (14.4) are above the European average. There is no comparative data for Russia. The small number of graduates specializing in MST in Estonia (and also in Latvia) could be one indicator of little interest in science, and it could be the cause of the weak relationship between SM and GEP.

At the same time, there are countries with a significantly stronger relationship between SM and GEP ($r = .42$). The reasons for differences in the magnitude of the relationship can also lie in differences in the educational and value systems of different countries. The fact that in Finland and Sweden the number of graduates specializing in MST per 100,000 citizens is above the European average could be due to the general valuation of science in the society. An educational system is very closely connected with the country's social-political situation. Rindermann (2008) has shown that education influences the democratization of a country.

It is possible that the political and social conditions of the country are a reason for differences in students' investment and their inner motivation towards knowledge. For example, they might be the direct result of government's educational and social policies, or they might have developed during the course of history, cultural and political development. This leads us to our next research question, namely, the relationship between students' achievement, attitudes and development of the society.

Acknowledgements

The preparation of this article was supported by a Primus grant (#3-8.2/60) from the European Social Fund to Anu Realo and by the Estonian Centre of Behavioural and Health Sciences.

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