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DEVELOPING OF FACTOR STRUCTURE FOR LEARNING STRATEGIES OF ESTONIAN STUDENTS IN MATHEMATICS AT THE UNIVERSITY LEVEL

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Abstract

This research reports learning strategies of the first-year Estonian university students in mathematics. The data were collected during two years from 440 university students of different disciplines. The respondents were among students who take at least one compulsory mathematics course during their first study year. The participants filled out a Likert-type questionnaire that was developed using previously published instruments. The aim of this research was to examine the 69-item LIST questionnaire first time for Estonian university students. By means of an exploratory factor analysis, 9 factors out of 12 were confirmed. The research confirmed most of the components identified in earlier studies. It validates the use of the instrument in further studies of learning strategies at the university level in Estonia. This gives a positive signal about the usefulness of the instrument, as the component structure remains stable in different populations.
Keywords: *learning strategies, LIST questionnaire, mathematics education, mathematics related affect, university mathematics.*

Introduction

Research into mathematics education at the tertiary level may be itself an interesting field of research and may give rise to useful results for teachers in all educational levels to apply to their teaching. This research is so far, the only study of students' learning strategies in mathematics in Estonia at the university level and until now the area has been unexplored in Estonia. One of the strategic objectives of the Estonian higher education strategy is to motivate students to study natural and exact sciences and technology at the tertiary level (Estonian Ministry of Education and Research, 2006). Estonian students showed excellent achievement in the PISA studies, and Estonian students know that mathematics is important (Estonian Ministry of Education and Research, 2013; 2017). PISA 2012 and 2015 showed that Estonia's basic school students rank among the best in the world while being at the absolute top in Europe (Estonian Ministry of Education and Research, 2017), but at the same time they conclude that mathematics is boring (Kislenko, 2009). However, at the university level natural sciences, pure science and technology are not popular fields of study and the dropout rate is high.

The research at the tertiary level in Estonia is limited to a few research papers (Kaldo & Hannula 2012; Kaldo, 2014), which indicated that females are more motivated to study

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mathematics. These recent studies (Kaldo & Hannula, 2014; Kaldo, 2014) showed that more than two-thirds of the students think that what they are learning in mathematics is interesting. The problem is that more than half of the students do not understand everything that they have done in mathematics over the last year (Kaldo, 2014). This calls for a change in learning strategies in mathematics at the university level.

In the following are given the selection of approaches to capture learning strategies which reflect the importance of affective and motivational issues. Pintrich and DeGroot (1990) developed a questionnaire "The Motivated Strategies for Learning Questionnaire" (MSLQ) to measure the types of learning strategies and academic motivation used by college students and uses a Likert scale. There are essentially two sections to the MSLQ, a motivation section, and a learning strategies section. In the MSLQ the learning strategy section includes 31 items regarding students' use of different cognitive and metacognitive strategies (Pintrich, Smith, García & McKeachie, 1991). By Griese, Lehmann & Roesken-Winter (2015) the Approaches to Studying Inventory (ASI) by Entwistle and Ramsden (1983) and its refinements (ASSIST by Tait, Entwistle & McCune, 1998; ALSI by Entwistle & McCune 2004) feature the main distinction of categorizing learning behaviour as being of either strategic or of apathetic approach (Griese, Lehmann & Roesken-Winter, 2015). Weinstein and Palmer (2002) described another self-report instrument to assess students' learning strategies, which is the Learning and Study Strategies Inventory (LASSI). This instrument LASSI (Weinstein & Palmer, 2002) covers thoughts, behaviours, attitudes and beliefs in relation to successful learning that can also be fostered by interventions (Griese et al., 2015).

Another well-known questionnaire is the German LIST questionnaire (Wild & Schiefele, 1994), which is based on the same classification as MSLQ and takes up aspects from LASSI as well (Griese et al., 2015). LIST questionnaire has been modified and tested several times since 1994 and has been applied in the context of many subjects, including mathematics (Liebendörfer, Hochmuth, Schreiber, Göller, Kolter, Biehler, Kortemeyer, & Ostsieker, 2014; Griese et al, 2015). Griese et al. (2015) examined the 69-item LIST questionnaire for 2374 STEM students from different engineering courses at Ruhr-Universität Bochum in Germany, typically predominantly males. Gómez-Chacón, Griese, Rösken-Winter and Gonzàlez-Guillén (2015), explored by means of the LIST questionnaire learning strategies for two samples of 113 Spanish and 159 German engineering students. Griese et al. (2015), research focuses on engineering students in their first semester at the university. Out of the students questioned, 77.70 % are males, 22.30 % females in their study. In the paper Griese et al. (2015), learning strategies are understood "*as all kinds of planned and conscious learning behaviour and the attitudes behind it, involving observable actions (e.g. solving tasks, asking questions, taking notes) as well as thought processes (e.g. planning, reflecting) on the basis of both cognitive and affective-motivational dispositions*".(p. 2)

Therefore, the question is raised about how students use different learning strategies in mathematics. The latest research in Germany (Griese et al., 2015) gives one instrument, but no previous researches have explored Estonian university students' learning strategies in mathematics. The aim of this research was to use some of the published instruments on mathematical learning strategies first time in Estonia at university level. This instrument was then used to confirm its applicability in Estonia at the university level. In this research, the following research question was particularly pursued: What kinds of factor structure in learning strategies in mathematics do students from Estonia hold at the university level? We hope to get a reliable instrument and then later to respond to the research questions that will help solve the societal problems that were pointed out as the motivation to study and decreasing the dropout rate in universities. We must also concern later ourselves with helping students learn how to study mathematics because students must also accept some of the responsibility instead of relying only on the lecturers.

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Research Methodology

General Background

We are influenced by the work of Griese et. Al (2015) and for our research in Estonia, the decision was made in favour of the Griese et al. (2015) 69-LIST questionnaire which is modified and up-to-date. As there are no analogous Estonian questionnaires on learning strategies, this research opted for the LIST questionnaire, thus hoping for the further asset of a parallel instrument for different countries. The quantitative data were gathered in 2017 and 2018 from students of five universities of Estonia. Tallinn University of Technology (approximately 70,000 alumni) is the only technological university in Estonia, University of Tartu is Estonia's national university (around 13,000 students) and belongs to the top 1% of the world's most-cited universities and research institutions. The Estonian University of Life Sciences (number of students 2500) is one of top 100 universities in the world in the field of agriculture and forestry, Estonian Business School is the oldest privately owned business university in the Baltics with more than 1500 students. Estonian Aviation Academy (approximately 300 students) is a state-owned professional higher education institution educating and training specialists for Estonian aviation enterprises and organisations.

Sample of Research

This research was carried out in Estonia at the university level. A nationally representative study provides a strong basis for research at the tertiary level as well as for the conclusions and educational implications. In order to gain a complete picture and to get a representative sample, almost all the universities in Estonia were covered (a total of 5 universities in 2 cities: Tallinn and Tartu). In Estonia, there are only a few universities and they focus on different subjects. Data collected during two years (in the 2017 and 2018 spring semester) to get more data for analyses. The participants were 440 volunteer bachelor students taking at least one first-year compulsory math course at the university level at the universities introduced previously. The questionnaire was completed during the mathematics lectures that were compulsory for the students and participation was voluntary. There were 234 males and 206 females; 329 students studying in Estonian and 111 students studying in English (Figure 1).

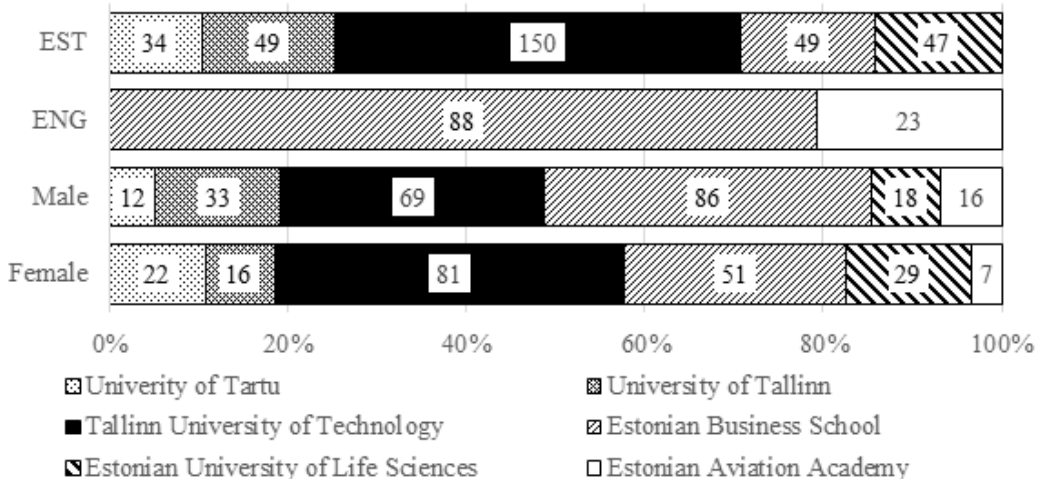

Figure 1. Counts (on coloured areas) and percentages of respondents' socio-demographic data.

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According to Estonian Educational Information System (www.ehis.ee), open for everybody, no confidential information included) there were 1461 bachelor students in year 2015/2016 who have mathematics course in their study program so the database is presenting population quite well. All results presented in groups and analysed used statistical methods.

Instrument and Procedures

The LIST questionnaire used in this research was developed in 1994 as part of a research project in Germany. The statements in the questionnaire are grouped into 13 topics (Wild & Schiefele, 1994). Griese et al. (2015) modified the original LIST questionnaire to 69-items LIST, they removed the scale Critical Checks because it did not seem appropriate for mathematics at the beginning of the university. By the same reason the 69-items LIST was used because this sample was first-year university students. In the research, a quantitative (questionnaire) research strategy was used. The questionnaire was used to study students' learning strategies in mathematics.

The questionnaire used in Estonia was translated before the pilot study into Estonian and back to English (Kaldo & Õun 2019, submitted). As one of the aims of the pilot study was to make a comparative analysis, then the translation had to have been carried out with a high degree of caution. Gorard's (2001) suggestion was followed during the study where he recommends that:

… if you are working in one language and translating your instrument into another language before completion (a common process for overseas students), then use the techniques of back translation as well. In this, the translated version is translated back into the original language by a third person as a check on the preservation of the original meaning. (p. 91)

The study in Spain (cf. Gómez-Chacón et al., 2015), showed that LIST keeps its qualities when being used in another country: "*after being translated into English and then into Spanish, the cognitive and metacognitive scales from LIST kept their reliability, an indication for the questionnaire's universal applicability*" (Gómez-Chacón et al., 2015).

Since the purpose of the research was to confirm the earlier scales on learning strategies (Griese et al., 2015), the original scales from the earlier research were used and their reliabilities were computed and the same component names were used: Organizing, Elaborating, Repeating etc. The Exploratory factor analysis used for computing factors. That statistical method has three main uses: 1) to understand the structure of a set of variables; 2) to construct an instrument to measure an underlying variable; and 3) to reduce a data set to a more manageable size while retaining as much of the original information as possible (Field, 2009).

Moreover, the structure of the learning strategies on mathematics was explored through calculating correlations among the reliable components.

Participants filled in a questionnaire on paper. The students were asked to respond on a 4-point Likert scale: strongly disagree, partly disagree, partly agree, and strongly agree). The students were given at least 30 minutes to fill in the questionnaire and told the questionnaire was anonymous and we collected 440 questionnaires.

Since the purpose of the research was to confirm the 69-item LIST of students' learning strategies in mathematics (Griese et al., 2015),

Data Analysis

The items from the earlier research were used and the reliabilities of the modified scales were computed (Table 1).

In this research Field's (2009) directions were followed. The decision to use the exploratory factor analysis for the questionnaire came from the following reasons: 1) the

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previous questionnaires were not tested in a similar population; i.e., these were used in Estonia for the first time; 2) the sample in this study is large and varied enough to make an exploratory analysis compelling. In this research, an exploratory factor analysis was done, which revealed factors similar to the earlier studies. For the exploratory factor analysis, the maximum likelihood method with direct oblique rotation was used to determine useful and statistically robust dimensions regarding this construct.

This method of factor analysis allows for the making of inferences from sample to population; the sample of 440 students is, therefore, large and adequate enough. Oblique rotation is used when factors are allowed to correlate (Field, 2009). The factors of the learning strategies in mathematics cannot be regarded independently of each other; therefore, correlations among factors should be allowed. In that case, an oblique rotation will lead to a better estimation of factors since it derives factor loadings based on the assumption that they are correlated (Fabrigar, Wegener, MacCallum, & Strahan, 1999). The Kaiser criterion is based on the idea that the eigenvalues represent the amount of variation explained by a factor and that an eigenvalue of 1 represents a substantial amount of variation and therefore the recommendation is to retain all factors with eigenvalues greater than 1 (Field, 2009). The program SPSS with the Kaiser criteria "eigenvalue > 1" gave a suggestion to use 17 factors. Field (2009) argued that with a sample of more than 200 participants, the Catell's scree-test provides a fairly reliable criterion for factor selection. According to the Cattell's scree–test, after an inspection of the scree plot, the proper number of factors appeared to be between 7 and 8. A 12-factor solution for the whole survey was used, because a 12-factor solution corresponded with the number of factors predicted from the original studies. Another reason was that some factors contained only two items factor solutions or their Cronbach alphas were low. Items which had communalities of less than 0.3 were removed, because these lowest communalities are not significant (Hair, Anderson, Tatham, & Black,1998). Moreover, the structure of the view of mathematics was explored through calculating correlations (Hinkle, Wiersma, & Jurs, 2009) between the reliable components in SPSS. At least moderate correlations coefficients that are greater than 0.5 are presented in this study. In addition, we also calculated the mean scores and standard deviations for the whole sample (n=440) on each of the components.

Reliability and Theory of Uniting Two Database

Reliability characterises the stability, consistency and suitability of the methodology used. Reliability shows how well the results of repeated measurements (by either the same researcher or different researchers) carried out in the same circumstances coincide (Kask, 2009; Laius, 2011; Kaldo 2015). Reliability also indicates whether a certain indicator measures consistently and continuously (Kask, 2009; Laius 2011). In other words, how reliable is the result of the measurement (Kask, 2009; Laius, 2011)? In this study, the Cronbach's alpha was used as a measure of the internal consistency of the instrument and its subscales, which is the most widely used measure (Hair et al., 1998). If the reliability coefficient is 0.70 or higher, it is considered "acceptable" in most social science research situations (Hair et al., 1998).

There are many studies using data collected during different years by the same questionnaire and it is important to compare the results sameness before uniting different year's databases. For continues data the best method is a two sample (or an independent sample) T-test and it is a commonly utilized design for a straightforward comparison of two independent groups in psychological research (Goenen, Johnson, Lu, & Westfall, 2005; Kruschke, 2013). By Jeon and De Boeck (2017) *in a two-sample setting, testing H0 based on the independent sample T-test. The test statistic can be computed as , where and are the sample means for Groups 1 and 2, respectively, and is the estimated SE of the difference between the means. The t-statistic follows the T_v distribution with the degrees of freedom $v=N_1+N_2-2$. The two-sided p*

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value can be computed as ; that is, the area under the sampling distribution of the t-statistic to the left and the right of the absolute test statistic value when the null distribution is true. (Jeon, & De Boeck, 2017) The statistical program SPSS Statistics 24.0 was used for the data analysis.

Results of Research

The summarized results are presented in Table 1. The Cronbach's alpha showed reliability. The mean scores and variances for the whole sample ($n = 232$) on each of the components were also calculated. The original Cronbach's alpha is the alpha which is used in earlier studies of previously published instruments (Wild & Schiefele, 1994).

Table 1. The twelve factors of the students' learning strategies in mathematics.

Factors (number of items)	Sample item	Original Cronbach's alpha	Cronbach's alpha in the research	Mean	Std. deviation
F1 Organizing (8)	I go over my notes and structure the most important points.	0.82	0.786	2.68	0.56
F2 Elaborating (8)	I think of practical applications of new concepts.	0.77	0.796	2.73	0.54
F3 Repeating (7)	I read my notes several times in a row.	0.73	0.747	2.42	0.54
F4 Metacognition: Planning (4)	I plan in advance in which order I want to work through the subject matter.	0.64	0.644	2.58	0.61
F5 Metacognition: Monitoring (4)	I ask myself questions on the subject matter in order to make sure that I have understood everything correctly.	0.64	0.628	2.37	0.61
F6 Metacognition: Regulating (3)	Confronted with a difficult subject matter I adapt my learning strategy accordingly.	0.64	0.666	2.76	0.60
F7 Effort (8)	I make an effort even though the subject matter may not suit me well.	0.74	0.772	2.84	0.49
F8 Attention (6)	When I am learning I notice that my thoughts tend to stray.	0.90	0.903	2.58	0.70
F9 Time management (3)	I work according to a schedule.	0.83	0.707	2.35	0.57
F10 Learning Environment (5)	I work in a place that makes it easy to concentrate.	0.71	0.740	2.83	0.54
F11 Peer Learning (7)	I work on tasks together with my peer students.	0.82	0.85	2.56	0.63
F12 Using Reference (4)	I search for explanatory material if certain facts are not completely clear.	0.72	0.806	3.05	0.64

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The Cronbach's alpha used to measure reliability of factor items. It is commonly used as a measure of the internal consistency or reliability of factors for a sample of examinees. The mean scores and variances for the whole sample (n = 440) on each of the components were also calculated. In our study, the factor analysis confirmed 9 factors of 12. In this study, the factor analysis confirmed factors: F1 Organizing, F2 Elaborating, F3 Repeating, F7 Effort, F8 Attention, F9 Time management, F10 Learning Environment, F11 Peer Learning and F12 Using Reference. Three factors did not confirm for low reliability: F4 Metacognition: Planning; F5 Metacognition: Monitoring and F6 Metacognition: Regulating. By using the same number of questions as in the initial factors, in the factors F9 Time management, F10 Learning Environment the reliability was less than 0.7 and therefore we removed one question in both factors and we got reliable factors.

Compared with pilot study, three factors did confirm low reliability: F4 Metacognition: Planning; F5 Metacognition: Monitoring and F6 Metacognition: Regulating.

To compare two-year sample similarities independent samples t-test was carried out (Table 2). There were statistically significant differences between first and second year in F1, F7, F8 and F12 but test results for these factor items and also for factors did not confirm big differences of means by years (the mean differences were 0.17-0.29) so there is no reason to take these two year samples as separate databases. In the first year questionnaire, some questions needed recast for better understanding, so some differences could appear from that. Reliability analysis confirmed the same factor structure for both years so one can conclude these two-year samples can be united as one.

Table 2. Factors t-test results.

	Group Statistics					*t*-Test
Factors	**Year**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**Significance**
F1	2017	232	2.6061	0.55572	0.03649	.005
	2018	208	2.7539	0.54557	0.03783	
F2	2017	232	2.6945	0.53589	0.03518	.119
	2018	208	2.7744	0.53406	0.03703	
F3	2017	232	2.3822	0.54823	0.03599	.144
	2018	208	2.4577	0.53202	0.03689	
F4	2017	232	2.5420	0.58675	0.03852	.114
	2018	208	2.6322	0.60626	0.04204	
F5	2017	230	2.3402	0.59623	0.03931	.328
	2018	208	2.3970	0.61697	0.04278	
F6	2017	232	2.7763	0.57281	0.03761	.561
	2018	208	2.7430	0.62929	0.04363	
F7	2017	232	2.8959	0.48878	0.03209	.008
	2018	208	2.7713	0.49023	0.03399	
F8	2017	232	2.5042	0.68433	0.04493	.017
	2018	208	2.6637	0.70833	0.04911	
F9	2017	232	2.3103	0.56131	0.03685	.107
	2018	208	2.3978	0.57322	0.03975	
F10	2017	232	2.8138	0.52381	0.03439	.573
	2018	208	2.8430	0.56333	0.03906	

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F11	2017	232	2.5695	0.62946	0.04133	.824
	2018	207	2.5560	0.63720	0.04429	
F12	2017	232	3.1070	0.58647	0.03850	.035
	2018	207	2.9791	0.68317	0.04748	

Initially, the structure of the students' learning strategies was obtained (Table 3). Relations between the factors were calculated for the confirmed nine factors.

Table 3. Correlations among the factors.

	F1	F2	F3	F7	F8	F9	F10	F11	F12
F1 Organizing	1								
F2 Elaborating	.357**	1							
F3 Repeating	.504*	.194*	1						
F7 Effort	.451**	.267**	.389**	1					
F8 Attention	-.134**	-,105*	-.033	-.289**	1				
F9 Time management	.284**	.216**	.259**	.346**	-.112*	1			
F10 Learning Environment	.313**	.238**	.222**	.347**	-.130**	.320**	1		
F11 Peer Learning	.244**	.133**	.182**	.133*	.032	.071	.1597	1	
F12 Using Reference	.317**	.339**	.269**	.429**	-.103*	.151**	.2267**	.227**	1

Table 3 shows that nearly all dimensions correlate statistically significantly with each other. All correlations with the sign ** are significant at the level .01 (2-tailed). Correlations with the sign * are significant at the .05 level (2-tailed). The results of the correlation analysis showed that nearly all the factors correlated statistically significantly with each other. However, the strength of the correlation in the survey (Hinkle, Wiersma & Jurs, 2009) varied from little, if any (.00 to .29) to low (.30 to .49) and moderate (.50 to .70). Moderate correlations are the following factors: Organizing (F1) and Repeating (F3) were found to correlate with a coefficient of .504. The correlations of the rest of the factors are weak. In the pilot study the same results were obtained.

Discussion

Research into mathematics education at the tertiary level may be itself an interesting field of research and may give rise to useful results for teachers in all educational levels to apply to their teaching (Alsina, 2001; Abdulwahed, Jaworski & Crawford, 2012). Based on studies carried out by researchers in other countries, it is clear that students' learning strategies in mathematics are important areas in mathematics education and need attention in an Estonian context. This study is so far the only investigation of students' learning strategies in mathematics in Estonia at the university level and until now the area has been unexplored in Estonia. If we look at researches at the tertiary level in other countries in the field of learning strategies in mathematics, then we cannot find many studies (for example, Gómez-Chacón et al., 2015; Entwistle & McCune, 2004). The latest research in Germany confirmed the instrument as acceptable instrument at the tertiary level.

Research question: What kinds of factor structure in learning strategies in mathematics do students from Estonia hold at the university level?

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In the research, we used the instruments developed by Griese et. al (2015) and this is the German LIST questionnaire, which is based on the same classification as MSLQ and takes up aspects from LASSI as well and it is up to date questionnaire for the university level students. The Cronbach's alpha is commonly used as a measure of the internal consistency reliability of a questionnaire. If the reliability coefficient is 0.70 or higher, it is considered to be "acceptable" in most social science research situations. In the Table 1 nine factors had a high Cronbach's alpha and their reliability for Estonian university students was confirmed. The reliability of three factors used in the study was not confirmed. However, those that were not found to be reliable were not far from the threshold level. The standard deviation of the item responses was very low, which may have contributed to the low reliability of the scale in this sample.

This research concluded with exactly the same results (Wild & Schiefele, 1994). The difference between the study of STEM students' learning strategies (Griese et al., 2015) was that in their study Metacognition factors were confirmed.

The self-criticism of our data collection is that the questionnaire was handed in on paper. For the manual insertion of data in the file for SPSS professional help was used. For web-based questionnaires, there is no need to insert data in the file, but the weakness is that in this case it is hard to get a large sample size. This was the reason why paper and pen were used for the questionnaires.

The scales had been previously tested on high school students and university students outside of Estonia, which suggest that the differences in reliability can be related to differences between samples (age, level of study, field of study, culture) or the translation of the items. This claim is coherent with Diego-Mantecón et al.'s (2007) conclusion that questionnaires can be sensitive to variables such as student age, gender and nationality.

Conclusions

Based on researches carried out by researchers in other countries, it is clear learning strategies in mathematics are important areas in mathematics education and need attention in an Estonian context. In this research the sample size and representativeness of all the universities is one of the strengths of the research. One task of the research was to check the reliability of the questionnaire. That means that we can use the questionnaire later for the survey. Nine reliable factors for students' learning strategies in mathematics were obtained. Based on the study analysis, the structure of the first-year baccalaureate students' learning strategies in mathematics is coherent with the structure from other researches' (Wild & Schiefele, 1994; Griese et al., 2015) structures. This gives a positive signal about the usefulness of the instrument for learning strategies in mathematics, as the component structure remains stable in context of Estonia population at university level.

The study confirmed same aspects of learning strategies as Griese (2015) reported. Learning strategies in mathematics are understood as all kinds of planned and conscious learning behaviour and the attitudes behind it, involving observable actions as well as thought processes on the basis of both cognitive and affective-motivational dispositions, can be identified and validly measured as separate components of Estonian university students' learning strategies in mathematics. However, some robust differences in scale reliabilities beg for caution when importing instruments to new cultural contexts.

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