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Validation and adaptation of the questionnaire on science motivation in the Russian context

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Abstract

The ability to read and understand scientific information is necessary for the growth of a scientific society. Moreover, the reasons why they want to study different scientific fields are diverse. The validity and reliability of the Science Motivation Scale in Russia were investigated for this study. The first step was to determine whether or not the scale items used in the study were linguistically valid. Then, an exploratory factor analysis of the data collected from 667 college students was conducted. The next step was to conduct a confirmatory factor analysis. As a direct result, research was conducted on the correctness and reliability of SMS in the Russian context. According to the research results, thirty components and five contributing variables were found. It was suggested that future researchers conduct studies on the validity and reliability of SMS with many different populations.

Keywords: adaptation scale, psychometric properties, Russian undergraduate students, science motivation

INTRODUCTION

Changes in society lead to corresponding shifts in the behaviors and skills required of people. For example, not all skills considered appropriate for the 21st century today will be among the most important skills expected of individuals 200 years ago. According to Ward and Roden (2016), science is one of the disciplines that significantly influences the development of certain skills and abilities. The goal of science teachers is for all students, regardless of prior knowledge or ability, to graduate from science classes with the essential knowledge and skills needed to make decisions based on logic and to understand the processes underlying the science they encounter in the media and their everyday lives (Glaze, 2018).

The National Science Foundation (NSF) (2017) noted that reports had highlighted the need to address student engagement and career success in science, technology, engineering, and mathematics (STEM). While enrollment has improved in certain STEM areas, there is still a deficit in pursuit and persistence in STEM areas (National Science Foundation, 2017).

The scientific environment and technologies are rapidly changing. For many, the scientific practices, tools, and thought processes they were taught have little to do with contemporary research's interactive and dynamically expanded activities (Glaze, 2018). It is suggested that integrating the arts with STEM (Science, Technology, Engineering, and Mathematics) will make science topics in school more interesting to a wider range of students, including those who are not interested in STEM (Henriksen, 2014; Ng & Fergusson, 2020; Sen, 2022). Reports emphasize the need to improve student

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Contribution to the literature

- This study explores the validity and adaptability of the science motivation questionnaire in the Russian setting.
- Using EFA and CFA, the current analysis focuses on the science motivation scale.
- It contributes to the science literature by developing a valid and reliable science motivation questionnaire for the Russian setting.

engagement and subject matter achievement in science, technology, engineering, and mathematics (STEM) (Dixon & Wendt, 2021).

Student interaction with science and engineering in school is unsatisfactory, indicating a decline in motivation, attitude, and interest (Potvin & Hasni, 2014; Schönfelder & Bogner, 2020; Belayneh, 2021). Motivational variables impact student effectiveness in science learning (Cavas, 2011). Numerous studies have highlighted the importance of student motivation in learning. Most research has shown that positive motivation to learn improves students' academic achievement during their school years and is also one of the most important factors for their future success (Riswanto & Aryani, 2017; Van Vo & Csapó, 2021). Studies in educational research have frequently examined students' interests, motivations, and attitudes toward science (Drymiotou et al., 2021; Osborne et al., 2003; Potvin & Hasni, 2014). Positive motivation to learn science is critical to becoming a scientifically literate citizen (Aristeidou & Herodotou, 2020).

The motivation in question is usually referred to as "science motivation," i.e., motivation associated with scientific inquiry (Wicaksono et al., 2018). A person's internal motivation for science is what initiates, guides, and sustains their learning behaviors related to science. If learners are motivated to study science, they will at least have attitudes and actions that lead them to engage in the motivational process. When learners are encouraged to study science, it is a solid start for them to study science (Schumm & Bogner, 2016a; Simpkins et al., 2006). Science motivation affects students' achievement-related behaviors (Badru & Owodunni, 2021; Liou, 2021; Schumm & Bogner, 2016b; Singh et al., 2002; Wicaksono et al., 2018). Some aspects of motivation are influenced by personal characteristics, while others are influenced by direct and indirect contacts in family, school, and society (Van Vo & Csapó, 2021).

A distinction must be made between intrinsic and extrinsic motivation. Intrinsic motivation is described as engaging in an activity because of its intrinsic value or the sheer pleasure of it (Ryan & Deci, 2000). People can control (self-direct) their activities when intrinsically motivated (Deci et al., 1991). On the other hand, extrinsic drive refers to the pursuit of tangible outcomes, such as better employment opportunities or a good grade (Ryan & Deci, 2000). Extrinsic motivation refers to actions influenced by an external cause (Deci et al., 1991).

Several instruments have been developed based on these different methods to measure science motivation in an educational context. The Science Motivation Questionnaire II was developed by Glynn et al. (2009) and includes five subscales: intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation (Glynn et al., 2011). Józsa (2014) developed the Subject Specific Mastery Motivation Questionnaire, which includes five-point Likert scale items for six school subjects (reading, mathematics, science, English as a second language, art, and music) and enjoyment of school mastery. The questionnaire included five-point Likert scale questions on self-efficacy, active learning techniques, the value of science learning, achievement goals, goal attainment, and stimulation of the learning environment. There is no robust and accurate instrument to measure science motivation in the Russian background in the relevant literature. Therefore, this study aims to adapt and validate the science motivation scale for the Russian context. We used items from research (Glynn et al., 2009).

METHOD

This study attempts to validate the instrument. The methodology is based on the psychometric characteristics of the scale. It, therefore, uses both qualitative approaches.

Participants

The participants are undergraduate students studying at universities in Russia. Sixty-three percent of the participants are female, and 37 percent are male. The age distribution of participants is 17 years (1.9%), 18-19 (51.9%), 20-21 (24.1%), and 22 years and older (22%).

Data Collection Instrument

The science motivation scale adapted in this study was developed by (Glynn et al., 2009). In the original scale, there are five factors: 'intrinsic motivation and personal relevance', 'self-efficacy and evaluation anxiety, 'self-determination', 'career motivation', and 'grade motivation'.

Procedure

To conduct the validation of the Science Motivation Scale (SMS). The following procedures are used:

1. the original scale was translated into Russian by a group of translators.
2. another group of translators translated the scale from Russian into English.
3. each translator had more than five years of experience in translating academic studies.
4. The quality of the translation was checked for consistency with the original version.
5. a pilot version of the scale was applied to 10 students to check its comprehensibility and validity
6. application of the sample group to calculate the psychometric properties of the SMS.

Data Analysis

The psychometric properties of the SMS were assessed to determine its validity and reliability. First, it was determined whether the data followed a normal distribution. For large samples (n > 300), the skewness is between -2 and +2, and the kurtosis should not be greater than 7, indicating that the measurement has a normal distribution (Kim, 2013). Second, an exploratory factor analysis (EFA) was conducted. Williams et al. (2010) provides five steps for factor analysis: Data suitability check, factor extraction, factor extraction determination criteria, rotation method selection, and interpretation. In the first step, we review the sample size. The sample size is over 300, which is sufficient. Then we check the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity. In the second step, the principal axis factoring was preferred for the extraction method. Parallel analysis is used to determine the number of factors. In addition, the loading factor was greater than 0.4. In the fourth step, 'Promax' rotation was used as the rotation method.

Then, confirmatory factor analysis (CFA) was performed to investigate the factor structure. In addition, descriptive statistical studies and internal consistency analysis (Cronbach's alpha) were performed to determine the instrument's reliability. Several fit indices were used to confirm or reject the tested model: X2/df, the comparative fit index (CFI), the incremental fit index (IFI), the root mean square error of approximation (RMSEA), and its 95% confidence interval (CI), and the standardized residual mean square root (SRMR). Values of χ^2/df less than 3, values for the incremental fit index (CFI and IFI) around or above 0.95, and values of RMSEA and SRMR less than or very close to 0.06 and 0.08 were considered indicative of a good fit of the model to the data (Kline, 2005).

RESULTS

First, exploratory factor analysis is conducted, followed by confirmatory factor analysis to validate the results. The final section discusses the results in terms of reliability.

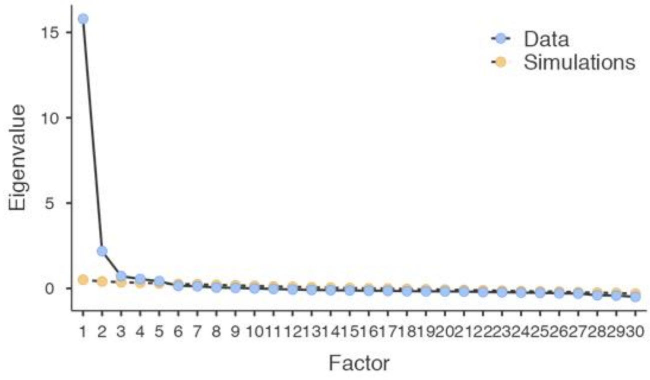

Figure 1. Expletory *Factor Analysis Scree Plot*

Factor Analysis

The KMO and Bartlett's test results were analyzed for sample adequacy. The KMO value was calculated to be 0.970, and Bartlett's test was calculated to be χ^2=18204, df= 435, p < 0.001. From these results, it was concluded that the sample data could be subjected to factor analysis.

In the factor analysis, the number of factors was calculated by a "parallel analysis". According to Williams et al. (2010), the parallel analysis provides more accurate results. A similar analysis yielded five factors (**Figure 1**). The minimum value of 0.4 is defined for the factor loadings in the factor structure. The "principal axis" method was preferred as the extraction method. The "promox" method was used for rotation to obtain a stronger factor structure.

While the lowest factor loading was 0.435 within the five-factor structure, the highest was 0.989. Item 30 is included in both the first and second factors. Since there is a difference between the factor loadings (0.572-0.439=0.133 > 0.1), it is assumed that there is no overlap. Consequently, item 30 is included in Factor 1. The items in Factor 1 were examined, and Factor 1 was named "self-efficacy." The second factor was called "career motivation" because the items in the second factor were related to careers. All of the reversed items were in the third factor. Because all of the items related to negative emotions, the third factor was "anxiety." The items in the fourth factor are related to grades and achievement. Therefore, the fourth factor was named "grade motivation." The items in the last factor related to intrinsic motivation, so the factor was called "intrinsic motivation."

The factor "self-efficacy" explains only 19.15 percent of the total variance. Thus, the scale cannot be accepted as an independent factor. The scale with five factors and 30 items explains 68.6 percent of the total variance (**Table 1**, **Table 2**).

Table 1. Factor loading for each factor

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
IT_1. The science I learn is more important to me than the grade I receive					0.435	0.488
IT_2. I find learning science interesting					0.724	0.260
IT_3. I like science that challenges me					0.778	0.247
IT_4. Understanding science gives me a sense of accomplishment					0.443	0.391
IT_5. Earning a good science grade is important to me				0.493		0.458
IT_6. I am confident I will do well on science assignments and projects				0.740		0.280
IT_7. I believe I can master the knowledge and skills in the science course				0.689		0.284
IT_8. I am confident I will do well on science tests				0.738		0.282
IT_9. I believe I can earn a grade of "A" in the science course				0.656		0.346
IT_10. I think about how learning science can help me get a good job		0.762				0.271
IT_11. I think about how the science I learn will be helpful to me		0.839				0.190
IT_12. I think about how learning science can help my career		0.989				0.153
IT_13. I think about how I will use science I learn		0.927				0.149
IT_14. The science I learn is relevant to my life		0.619				0.308
IT_15. The science I learn has practical value for me		0.657				0.237
IT_16. I am nervous about how I will do on the science tests*			0.844			0.225
IT_17. I become anxious when it is time to take a science test*			0.942			0.156
IT_18. I worry about failing science tests*			0.803			0.222
IT_19. I am concerned that the other students are better in science*			0.743			0.400
IT_20. I hate taking the science tests*			0.711			0.600
IT_21. I enjoy learning science	0.607					0.261
IT_22. I like to do better than the other students on the science tests	0.586					0.433
IT_23. I think about how my science grade will affect my overall grade point average	0.465					0.383
IT_24. I put enough effort into learning the science	0.781					0.300
IT_25. I use strategies that ensure I learn science well	0.745					0.310
IT_26. It is my fault if I do not understand science	0.467					0.587
IT_27. I prepare well for science tests and quizzes	0.869					0.315
IT_28. If I am having trouble learning the science, I try to figure out why	0.765					0.270
IT_29. I expect to do as well as or better than other students in the science course	0.760					0.314
IT_30. The science I learn relates to my personal goals	0.572	0.439				0.296

Note. 'Principal axis factoring' extraction method was used in combination with a 'promax' rotation
* Items were reversed coded.

Table 2. The Variances and Total Variances of the Factors

Factor	SS Loadings	% of variance	Cumulative %
Self-Efficacy	5.75	19.15	19.2
Career Motivation	5.52	18.41	37.6
Anxiety	3.78	12.60	50.2
Grade Motivation	3.13	10.43	60.6
Intrinsic Motivation	2.40	8.01	68.6

Confirmatory Factor Analysis

A CFA test model analysis showed that the latent variable is true and can be further processed to validate the structural model (**Table 3**).

The first model fit indices are acceptable but not good because χ^2/df is greater than 3. Adding the covariance connections recommended by the program resulted in the creation of the new model. When examining the final model fit indices, we observe that the CFI and TLI values

Table 3. Fit indices for the first model and last model

	χ^2/df	CFI	TLI	SRMR	RMSEA	RMSEA 90% CI Low	RMSEA 90% CI High
Cut-off criteria	**≤ 3**	**>0 .90**	**> 0.90**	**< 0.08**	**< 0.08**		
First Model	1825/395=4.62	0.921	0.913	0.0525	0.0737	0.0703	0.0771
Last Model	1117/372=3.00	0.959	0.952	0.0466	0.0548	0.0511	0.0585

Note: **df**: degree of freedom, **CFI**: Comparative fit index, **TLI**: Tucker-Lewis index, **SRMR**: Standardized Root Mean Square Residual, **RMSEA**: Root mean squared error of approximation.

Table 4. Factor loading values, Z and P values

Factors	Indicator	Estimate	SE	Z	p
Self-Efficacy	IT_21	1.027	0.0381	26.9	< .001
	IT_22	0.925	0.0427	21.7	< .001
	IT_23	0.883	0.0427	20.7	< .001
	IT_24	0.953	0.0367	25.9	< .001
	IT_25	0.898	0.0352	25.5	< .001
	IT_26	0.783	0.0425	18.4	< .001
	IT_27	0.936	0.0371	25.2	< .001
	IT_28	1.018	0.0376	27.0	< .001
	IT_29	0.999	0.0389	25.7	< .001
	IT_30	1.005	0.0401	25.1	< .001
Career Motivation	IT_10	1.067	0.0393	27.2	< .001
	IT_11	1.101	0.0369	29.8	< .001
	IT_12	1.166	0.0380	30.7	< .001
	IT_13	1.157	0.0372	31.1	< .001
	IT_14	1.027	0.0390	26.3	< .001
	IT_15	1.058	0.0381	27.8	< .001
Anxiety	IT_16	1.168	0.0400	29.2	< .001
	IT_17	1.232	0.0393	31.4	< .001
	IT_18	1.177	0.0417	28.2	< .001
	IT_19	0.997	0.0449	22.2	< .001
	IT_20	0.753	0.0471	16.0	< .001
Grade Motivation	IT_5	0.817	0.0436	18.7	< .001
	IT_6	0.939	0.0361	26.0	< .001
	IT_7	0.969	0.0360	26.9	< .001
	IT_8	0.949	0.0358	26.5	< .001
	IT_9	0.927	0.0390	23.8	< .001
Intrinsic Motivation	IT_1	0.829	0.0405	20.5	< .001
	IT_2	1.064	0.0404	26.4	< .001
	IT_3	1.064	0.0404	26.3	< .001
	IT_4	0.989	0.0422	23.5	< .001

Table 5. Reliability results for factors and total scale

Factors	Items	Cronbach α	McDonald's ω
Self-Efficacy	10	0.941	0.942
Career Motivation	6	0.903	0.907
Anxiety	5	0.953	0.954
Grade Motivation	5	0.893	0.897
Intrinsic Motivation	4	0.872	0.874
Total	**30**	**0.925**	**0.952**

are more than 0.95, while the SRMR and RMSEA values are less than 0.08 (Hair et al., 2014). According to the CFA, the SMS is at a satisfactory level (**Table 4**).

The relationship between each item and the relevant factors is statistically significant at the p=0.001 level for all items. According to the CFA result, no SMS item should be deleted.

Reliability Analysis

The cutoff value is 0.7 for both reliability measurements (Hair et al., 2014). **Table 5** shows that each factor of Cronbach alpha and McDonald's value is greater than 0.8. It was also discovered that the full scale of Cronbach alpha value is 0.925, and of McDonald's is 0.952.

DISCUSSION AND CONCLUSION

This study aims to evaluate the psychometric properties of the Science Motivation Scale and to adapt and validate it for the Russian setting. The study was conducted in Russia in the spring of 2022.

The SMS was validated using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on 667 students. The EFA methodology is a multivariate statistical tool (Edwards & Bagozzi, 2000; Watkins, 2018). KMO (0.970) and Barlett's test (2=18204, df=435, p0.001) were calculated in EFA to determine the fit of the data. Both values are quite high (Yong & Pearce, 2013). The 'Principal Axis Factoring' extraction method was combined with a 'Promax' rotation. A parallel analysis was performed to determine the number of components. In a similar study, we compared real eigenvalues with eigenvalues in random order. Factors are retained if the real eigenvalues exceed the randomly ordered (Williams et al., 2010). After scree plot and parallel analysis, each item was categorized into five components.

Within the 5-factor structure, the lowest factor loading was 0.435, and the highest was 0.989. Because the items were not distributed similarly to the study factor structure (Glynn et al., 2011, 2009), factor labels were reconstructed by examining the items. Factor 1 was labeled self-efficacy after a review of the items that comprise it. The second item was titled career motivation because its content was associated with careers. There are no reversed items in the third factor. Since each item is associated with negative emotion, the third item was labeled anxiety. The items in the fourth component are associated with grade and achievement. Therefore, the fourth component was labeled "grade motivation." The last item was named "intrinsic motivation" because its items are associated with intrinsic motivation.

A CFA test model analysis was conducted to determine when the structure in the SMS was correct and to validate the structural model further. The CFI and TLI values are both above 0.95, but the SRMR and RMSEA values are less than 0.05 (Hair et al., 2014). The SMS is consistent with the conclusions of the CFA.

The overall scale has a Cronbach's alpha value of 0.925, while McDonald's is 0.952.

Consequently, research was conducted on the validity and reliability of the SMS in the Russian environment. Thirty items and five factors were identified after the analysis. It is suggested that future researchers conduct studies on the validity and reliability of SMS with multiple groups.

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