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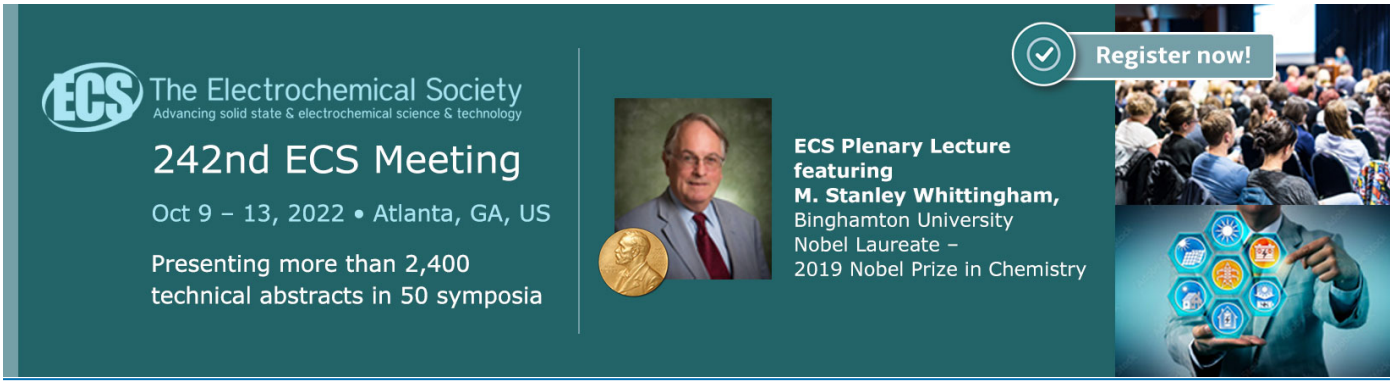

Kazakh and Russian Translation of FSMAS-SF Instrument

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Abstract:
Purpose of the study: The purpose of the study is to develop an instrument in both Kazakh and Russian languages that measures students' attitudes towards mathematics through translating a widely used 51-item instrument developed by Mulhern and Rae.
Methodology: This work utilized factor analysis in SPSS using Principal Component Analysis (PCA) with VARIMAX. To this end, the attitude test of Mulher and Rae consisting of 51 5-point Likert scale items in English were translated into Kazakh and Russian languages. The translated instrument is conducted amoing 378 university students in Kazakhstan. To test the internal consistency, the Cronbach alpha methodology was implemented.
Main Findings: The results revealed five underlying dimensions of the instrument with 37 items in both languages. These five scales are Success, Male Domain, Parent's Attitudes, Mathematics-Related Affect, and Usefulness scales. Kaiser-Meyer-Olkin (KMO) Barlett's test of sphericity threshold is reported to be 0.875 with chi-square 7106, degree of freedom 1275 and p-value less than 0.0001. The analysis show a very high overall Cronbach reliability coefficient of .91.
Applications of this study: This study can be used in any mathematics learning descilpine in higher education institutions where medium of instruction is either Kazakh or Russian to test whether students attitudes towards mathematics is improving or not. Besides, the instrument can be used to study correlation between attitudes towards mathematics and learning outcome in the field.
Novelty/Originality of this study: This is probably the first ever work done in Kazakh and Russian to develop a comprehensive instrument that measures students' attitudes towards mathematics.

Keywords: Attitude Test, Factor analysis, Higher Education, Mathematics Education, Translation

1. Introduction

From pedagocial point of view, students' attitudes towards their subjects play crucial role in their learning processes. Moreover, attitudes towards STEM subjects are reported to be significant factors that affect students' future career choices [1]. As many studies show, attitudes are good indcators of achievement in mathematics subjects [2, 3, 4, 5] and it was recommended for mathematics educators to

have methods to evaluate their students' attitudes towards mathematics [6]. However, to the best of authors' knowledge, we were unable to find any mathematics attitude tests in neither Kazakh nor Russian language. The main goal of this article is to develop mathematics attitude tests in both languages and study the factor analysis and validation of the scale.

2. Literature review

D.B. McLeod defines *affective domain a*s a variety of "beliefs, feelings, and moods that are generally regarded as going beyond the domain of cognition". He proposes a theoretical framework where attitudes, beliefs, and emotions that students have toward mathematics are considered three components of the affective domain [7]. All three play a crucial role in Mathematics education. Research on students' attitudes towards science and math continues to be one of the major research areas. Attitudes towards mathematics are one of the predictors of performance in the field [8].

[9] defines attitude as "a mental and neural state of readiness, organized through experience, exerting a directive or dynamics influence upon the individual's response to all objects and situations with which it is related." [10] gave a definition of attitude, they considered quite generic, as "a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object". [11] defines attitude as "a state of readiness, or tendency to respond in a given manner when confronted with certain stimuli". These definitions all include some expectation of response to a situation.

Many researchers have investigated the relationship between achievement in mathematics and attitude towards mathematics, see e.g. [12, 13, 14, 15], and references therein.

As with other psychological constructs, the attitudes are latent and are impossible to directly observe [16]. Hence attitudes are inferred from responses to an instrument designed to measure aspects of the target construct, such as attitudes towards mathematics.

There have been many attempts to construct an attitude measurement described in the literature. The Dutton Scale is one of the first measurements developed [17], used to scale "feeling" towards arithmetic. The early multidimensional mathematics attitude tests can be seen in [18], [19], [20], [21], [22]. Among these measurements the Fennema-Sherman mathematics attitude scale (FSMAS) became the most widely used and is considered as the most prominent scale [23]. FSMAS consists of nine scales: (1) The Attitude toward Success in Mathematics Scale (AS), (2) The Mathematics as a Male Domain Scale (MD), (3,4) The Mother (M)/Father (F) Scale, (5) The Teacher Scale (T), (6) The Confidence in Learning Mathematics Scale (C), (7) The Mathematics Anxiety Scale (A), (8) The Effectance Motivation Scale in Mathematics (E), (9) The Mathematics Usefulness Scale (U). The instrument was developed with the intention to "to gain more information concerning females' learning of mathematics as well as information concerning variables related to the election of mathematics courses" [21]. It has 108 Likert-scale items and takes around 45 minutes to complete. Later the number of scales was reduced to eight by [24] and then six [25]. In fact, the latter provided a shortened form (FSMAS-SF) of FSMAS with only 51 items without much sacrifice of reliability.

For more recently developed questionnaires on attitudes towards mathematics we refer to [26], [27], [28], [29], and [30]. Later, the FSMAS-SF was translated into different languages including Arabic [31], Chinese [32], and Malay [33].

Because of its wide use, and the fact that the FSMAS-SF has already been translated into other languages with success, it was decided that this was the best instrument to use as a starting point. The Russian translation of the part of FSMAS-SF was already used in [2].

3. Methododlogy

3.1 Participants

Table 1 summarizes the participants' backgrounds. The first and second rows provide information about the participants who took the survey in Kazakh and Russian languages, respectively. In total there were 378 students involved from Suleyman Demirel University in Kazakhstan. The "Mathematics mandatory" column includes students majoring in fields such as Mathematics, Mathematics education, Economics, and Computer Science. The column "Mathematics not mandatory" includes students from Social Sciences and Humanities. The reason why we included the latter is because all the students took

mathematics courses in their high school. The students who did not respond to the gender item were not counted in Males/Females columns. The age range was from 16 to 23, of which 196 were freshmen, 121 were sophomore, 15 were junior, and remaining 46 were senior university students.

Table 1: Background Summary of Participants

	Total	Males	Females	Age Mean (SD)	Mathematics mandatory	Mathematics not mandatory
Kazakh	185	68	109	18.23 (SD=1.36)	138	47
Russian	193	101	83	18.16 (SD=1.36)	151	42
Total	378	169	192	18.19 (SD=1.36)	289	89

3.2 The Instrument

The authors themselves translated the 51-item FSMAS-SF attitude test [25] into Kazakh and Russian with expert consultation and validation. These translated items were randomized into one paper-based instrument and completed by volunteer students during Fall semester in 2018. Each student was asked to select one of the two languages according to their comfort. Each 5-point Likert scale item was graded from 1 to 5, with 1 being "Strongly disagree" and 5 being "Strongly agree". The negatively worded items were reverse scored.

To develop and validate the construct, we carried out factor analysis using Principal Component Analysis (PCA) with VARIMAX rotation out of 51 scale items from [25]. Only loadings greater than |.40| were considered. Kaiser-Meyer-Olkin (KMO) Barlett's test of sphericity was conducted to see if the data should be factorized.

Cronbach's Alpha coefficients were computed to test the reliability of the survey.

4. Results

As mentioned above we aimed to adopt translation of the FSMAS-SF [25] attitude test into Kazakh and Russian. In the first attempt we tested reliability of the translated items with 6 scales as in [25] and the results are reflected in Table 2 where we report Cronbach alphas.

Table 2: Reliability of the translated items

Name of Scale	FSMAS-SF [25]	Kazakh translation	Russian translation
Attitude Toward Success in Mathematics	.87	.73	.73
Mathematics as a Male Domain	.85	.72	.72
Parent's Attitudes	.90	.80	.80
Teacher's Attitudes	.79	.73	.73
Mathematics-Related Affect	.93	.90	.90
Usefulness of Mathematics	.88	.84	.84
Total Scale	.93	.91	.91

To see if the reliabilities can be imporved, we decided to consider factor analysis to see if the reliability coefficients can be improved and whether the number of test items can be reduced. In the first attempt, we used Eigen value greater than one rule in PCA to extract number of scales as proposed by [34]. In this case the analysis produced 12-13 factors which is found to be too many compared to both [21] and [25]. Then, we decided to restrict the number of factors to 6 as Scree Plot shown in Figure 1 suggests, a step which is consistent with [25].

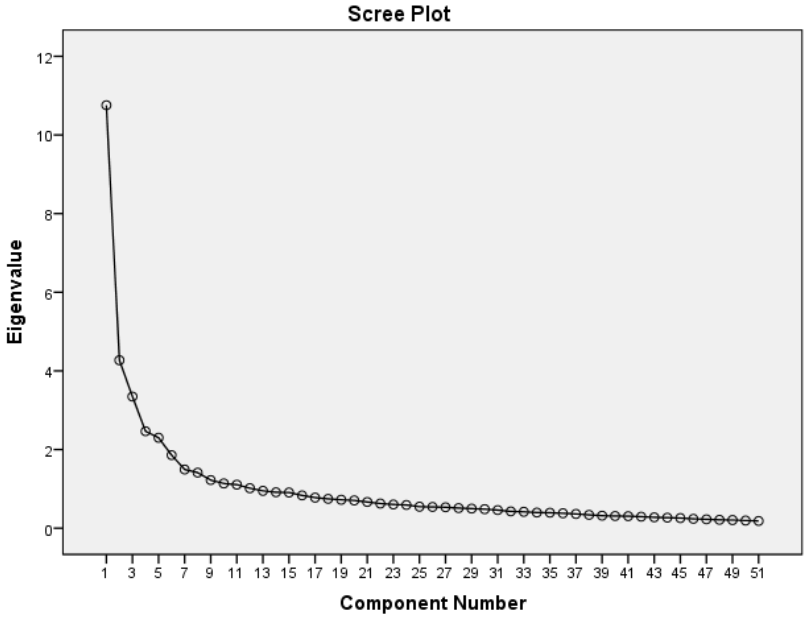

Figure 1: Eigenvalues and proportion of variance accounted for by the component number

However, on this six-factor analysis, the last factor produced an Alpha reliability coefficient of 0.58 for both translations. So, we decided to consider the first 5 factors which resulted in 37 items. Kaiser-Meyer-Olkin (KMO) Barlett's test of sphericity threshold is high (0.875) and a high significant chi-square $(\chi^2 = 7106, \mathrm{df} = 1275, \mathrm{p} < 0.0001)$. Our item coding follows [25]. The first scale consisted of 11 items A6, A7, A8, A9, A12, C1, C7, C10, C11, T8, T12 with loadings between 0.493 and .801 in rotated component matrix and is referred to as "Mathematics Related Affect Scale". The second scale is called "Usefulness" and is consisted of 7 items: U2, U3, U5, U6, U7, U8, and U9 with loadings from .518 to .710. The third scale composed of 8 items, S1, S2, S3, S4, S5, S6, T2, U4 with loadings between .516 and .709 which is named as "Success". The fourth scale "Parents" consisted of 5 items, F1, F2, F3, F5, M3 with loading from .474 to .707. The last scale is called "Male Domain" and is composed of 6 items, MD1, MD2, MD3, MD4, MD7, MD9 with loadings ranging from .534 to .668. The loadings state here were identical to both languages.

Table 3 shows the Cronbach alpha values for each of the new scales in both Kazakh and Russian.

Table 3: Cronbach Alpha values for each of the new scales in both Kazakh and Russian

Name of Scale	FSMAS-SF [25]	Kazakh translation	Russian translation
Success	.87	.83	.83
Male Domain	.85	.76	.76
Parent's Attitudes	.90	.79	.79
Teacher's Attitudes	.79	-	-
Mathematics-Related Affect	.93	.89	.89
Usefulness	.88	.86	.86
Total Scale	.93	.91	.91

One difference is that in the translated instrument Teacher's Attitude scale was dropped.

5. Discussion and Conclusion

In this article, we considered the transilation of famous construct due to [21], later shortened by [25], to measure students' attitudes towards mathematics into Kazakh and Russian. As discussed before, the original construct [21] had nine dimensions wheras the shorten form, FSMAS-SF, [25] reported to have

six dimensions. The reliability of these six dimensions are compared against the Kazakh and Russian translations in Table 2. The findings show that the Cronbach alphas of the translated scales are lower than reported in the original FSMAS-SF [25], yet they are all greater than .70 which is assumed to be acceptable. This provided further evidence to internal reliability of FSMAS-SF. Hence, in principle it is possible to keep all these translated 51 items. However, three scales are very close to the 0.70 threshold and we decided to run the factor analysis for futher exploration of the translated construct.

The results of the factor analysis with only five dimensions are given in Table 3. We clearly see significant improvements in the Cronbach alphas compared to six dimensional construct. Moreover, it is much shorted with 37 items compared to 51-item FSMAS-SF [25] and original 108-item FSMAS [21] while the relaibilities are comparable.

In the final version of the translated questionnaire we had Teacher's Attitude scale dropped leaving only five dimensions. The reason could be that the instructor-student relationship at the university study is not as significant as in high school education. On the other hand, some of the items from Teacher's Attitude moved to other scales. For example, T8 "I have found it hard to win the respect of math teachers" and T12 "I have had a hard time getting teachers to talk seriously with me about mathematics" were enter into Mathematics Related Affect Scale which makes sense as this scale is about anxiety and confidence. We also see one Teacher's Attitude item T2 "My teachers think I'm the kind of person who could do well in mathematics" entered into Success scale with no surprise.

In conclusion, the translated test provides a very useful tool for instructors teaching mathematics in Kazakh or Russian to measure university students' attitudes towards mathematics. This can help the pedagogs to modify their curriculum and teaching methodologies to improve the learning process. Moreover, the developed construct is more likely to help local researchers in psychology and education.

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