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Adaptation of the Questionnaire that Measures Students' Motivation toward Science Learning (SMTSL) into Bulgarian Version of Students' Motivation toward Chemistry Learning Questionnaire (BG SMTCLQ)

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Abstract

In educational practice and psychological research, the availability of a validated version of an original survey offers the opportunity of valid measurements obtained within the specific educational context and provides the possibility of international comparisons. The present study goal is to adapt the questionnaire that measures students' motivation toward science learning (SMTSL) for application in a different language (Bulgarian) and stresses particular learning - chemistry learning. The Bulgarian version of students' motivation toward chemistry learning questionnaire (BG SMTCLQ) afterwards is used in order to investigate Bulgarian upper secondary school students' motivation to learn chemistry for the first time. The sample consisted of 250 upper secondary and vocational students from 8 schools from 7 cities in Bulgaria. Factor analyses provided evidence for the validity of BG SMTCLQ. The six motivation components of the original instrument namely self-efficacy, active learning strategies, chemistry learning value, performance goal, achievement goal and learning environment stimulation is used. Findings of the study defined the validity of the BG SMTCLQ questionnaire and its reliability for Bulgarian upper secondary students' level. The results and the implication for using the BG SMTCLQ questionnaire in research and in classroom are discussed in the paper.

Keywords: motivation, attitudes, chemistry learning, teacher

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Introduction

Many secondary school students are poorly motivated and do not see science as relevant to their lives, because they find science a very difficult subject at school. The poor motivation of these students is believed to lead to low achievement (Beghetto, 2007). Research and literature in the field of science education has focused almost exclusively on attitudes towards science, paying little attention to research in the field of motivation of science learning (Breakwell & Beardsell, 1992; Koballa Jr., 1995; Oliver & Simpson, 1988; Piburn, 1993; Talton & Simpson, 1986).

The 1994 *Handbook of Research on Science Teaching and Learning* (Gabel, 1994) referenced the word *motivation* only three times, while the word *attitudes* appeared in more than 45 subject index listings and sub listings. It is surprising that so little work about motivation in science learning has been done until the end of the 20^{th} century. The study of the role of motivation in science had constantly gained the attention of science education researchers at the beginning of 21 century (Koballa & Glynn, 2007). Motivation is important (Tuan, 2005) because students' motivation plays an important role in their conceptual change processes (Lee, 1989; Lee & Brophy, 1996; Pintrich et al. 1993), critical thinking (Garcia & Pintrich, 1992; Kuyper et al., 2000), and science learning achievement (Napier & Riley, 1985). It is necessary to identify the nature and style of teaching and learning activities that engage students (Painter, 2011). To improve science engagement and achievement, it is critical to study and try to understand the motivational factors that affect engagement in science.

Over the last years everywhere in the world, including Bulgaria, there is low interest in science learning. It becomes less and less attractive to young people. In Bulgaria, science is in second place in the students' rank of the most disagreeable subjects after mathematics (Gendjova, 2017). Teachers say that motivation in science becomes lower in high-school because students do not see science as relevant to their lives, and find science very difficult. Research shows that from preschool to high school years, as a whole children's motivation decreases and they feel increasingly alienated from learning (Harter, 1981).

In Bulgaria, the only studies investigating the attitudes and motivation of science learning are via TIMMS and PISA. There are no studies on motivation to learn science or motivation to learn chemistry in our country. This could be because there is not a reliable and valid questionnaire in Bulgarian that measures students' motivation in science, and particularly in chemistry.

The present study goal is to adapt the questionnaire that measures students' motivation toward science learning (SMTSL) for application in a different language (Bulgarian) and stressing chemistry learning in particular. The Bulgarian version of students' motivation toward chemistry learning questionnaire (BG SMTCLQ) will be used afterwards (if proven to be valid) in order to investigate Bulgarian upper secondary school students' motivation to learn chemistry for the first time.

The specific research questions that have guided this study can be summarized as follows:

1. How valid is the measure of Bulgarian students' motivation toward chemistry learning questionnaire (BG SMTCLQ)?
2. Can the BG SMTCLQ be used to research students' motivation towards chemistry learning in Bulgarian secondary schools?

Literature Review

Motivation is a set of internal or external prerequisites that provoke people's behavior and determine the direction, intensity and duration of that behavior (Maehr, 1997*).* Researchers of students' motivation study what makes students move towards certain goals and engage in certain behaviors. Traditionally, behavioral theories have characterized motivation in terms of increased probability of behavior, occurring as a result of a stimulus or an effect or reinforcement. More recently, views and definitions of motivation have been developed within the social-cognitive framework of human learning (Bandura 2001, 2005a, 2005b, 2006). Social cognitive theory is designed to "explain how people acquire competencies, attitudes, values, styles of behavior, and how they motivate and regulate their level of functioning" (Bandura, 2006, p. 54).

In science educational literature, motivation is considered as "a complex multidimensional construct that interacts with cognition to influence learning" (Taasoobshirazi & Sinatra, 2011). Pintrich, Marx and Boyle (1993) adopted four general motivational constructs as potential mediators of the learner's conceptual changes that may influence science learning. The four constructs are goals, values, self-efficacy and control beliefs. It is essential to add to these the following contextual factors: classroom environment, the teacher, the nature of the academic tasks, and the assessment processes. These moderate the interaction between motivational constructs and science learning.

Motivation in education can be summarized as a student's willingness to undertake and persist in challenging tasks, seek help, and endeavor to perform well in school (Meece, Anderman & Anderman, 2006). The question of how to motivate students in school is one that has been frequently posed but has proved challenging to answer. Motivational research provides an understanding of the factors influencing motivation (attribution theory, self-efficacy theory, expectancy-value theory, self-theories, achievement goal theory, and self-determination theory), but the application of these factors within the classroom is linked to teacher beliefs and perceptions surrounding motivation (Hardre & Hennessey, 2013). Motivated students achieve academically by engaging in certain behaviors, such as studying, question asking, advice seeking, and participating in classes, labs and study groups (Shunk et al, 2008). Sanfeliz and Stalzer (2003) thus believe that one of the most important instructional responsibilities of the teacher is to foster students' motivation to learn. According to them, motivated students enjoy learning science, believe in their ability to learn, and take responsibility for their learning.

Motivation in education is very difficult to measure. This is partly because motivation to learn is very difficult to describe operationally. The key to measuring motivation must be to look for behaviors indicating high motivation and low motivation. There are many motivation questionnaires used for this purpose in different educational studies (Midgley, 1993; Pintrich, 1991; Uguruglu, 1981). However, they are mainly developed by psychologists to understand students' general learning motivation not addressing, specifically, motivation for learning science. The increasing interest in students' motivation in science learning in recent years has triggered the development of instruments that measure students' learning motivation based on different theoretical perspectives.

Because motivation cannot be observed directly, it is inferred by measurements of factors that are believed to constitute or influence motivation (Schunk, 2004). Several scales have been designed to measure students' motivation to learn science (Tuan et. al, 2005; Glynn and Koballa, 2006; Glynn et al., 2009, 2011; Velayutham et al., 2011). The Science Motivational

Questionnaire (SMQ) was developed by Glynn and Koballa (2006) and has been used to measure college students' motivation to learn science. Glynn and his colleagues focused on five constructs that influence self-regulatory learning to develop and validate the Science Motivational Questionnaire II (SMQ II) (Glynn and Koballa, 2006; Glynn et al., 2007, 2009, 2011). SMQ II was later adapted and validated in the Greek language to measure Greek secondary school students' motivation to learn chemistry for the first time (Salta & Koulougliotis, 2015).

The Students' Motivation toward Science Learning (SMTSL) was developed by Tuan, Chin and Shieh (2005), and has been used to measure junior high-school students' motivation to learn science in Taiwan. The researchers identified six motivational constructs: self-efficacy, active learning strategy, science learning value, performance goal, achievement goal and learning environment stimulation. This questionnaire was also adapted in the Greek language to measure undergraduate student teachers with reference to physics learning (Dermitzaki et al., 2013) and in the Turkish language to measure primary students (Yilmaz & Çavas, 2007). Aydin and Uzuntiryaki (2009) developed and validated the "High School Chemistry Self-Efficacy Scale" to measure Turkish high school students' self-efficacy from the perspective of cognitive and laboratory competencies. There is yet another instrument called "Students' Adaptive Learning Engagement in Science Questionnaire", which was developed to measure Australian lower secondary students (Valayutham et al., 2011). In the questionnaire, the four constructs are goal orientation, task value, self-efficacy and self-regulation.

The most recently useful scales in educational research literature are SMQ II and SMTSL. Both scales appear to have good evidence for content validity and good criterion validity. Only one scale has combined the constructivist learning and motivation theories, and this is the SMTSL questionnaire.

Most learning strategy theories are based on the constructivist perspective of learning, which contends that meaning and knowledge are constructed by the learner through a process of relating new information to prior knowledge and experience (Olgren, 1998). It also emphasizes that the quality of learning outcomes depends on how well the learner organizes and integrates the information.

Based on constructivist theory (Mintzes et al. 1998; von Glasersfeld 1998), students take an active role in constructing new knowledge. When students perceive valuable and meaningful learning tasks, they will actively engage in the learning tasks, using active learning strategies to integrate their existing knowledge with new experiences; they do not use surface learning strategies, such as memorization. When students perceive that they are capable, think that conceptual change tasks are worthwhile, and want to gain competences, they will be willing to make a sustained effort and engage in conceptual change (Tuan et. al, 2005).

Present Study

Constructing a constructivist and motivational environment is important for meaningful science learning, especially for chemistry learning. When the positive effects of motivation on learning chemistry and achievement are desired, it is crucial to determine school students' motivations. Therefore, the motivational constructs can be investigated and activities that improve students' motivation to learn chemistry can be developed. This is the reason that assessing school students' motivation to learn chemistry takes an important role and therefore to find and adapt a questionnaire that measures students' motivation toward chemistry learning. A deep review of the science literature shows that the only scale which combines the constructivist learning and motivation theories is the SMTSL (the Students' Motivation toward Science Learning) questionnaire. The main purpose of the study is to adapt the SMTSL for application in a different language (Bulgarian) and stressing chemistry learning. Additionally, the Bulgarian version of students' motivation toward chemistry learning questionnaire (BG SMTCLQ) afterwards will be used to investigate Bulgarian upper secondary school students' motivation to learn chemistry for the first time.

The Context

In this section, a short description of the Bulgarian chemistry curriculum is made because the analysis of the results of each motivational study is related to the context of the existing curriculum. The Bulgarian chemistry curriculum is comprised of compulsory, core curriculum and optional elective study courses. Compulsory education provides the attainment of the general education minimum, which is compulsory for all schools and is the basis of general education. Optional courses provide additional instruction within the subjects from the cultural and educational areas corresponding to the interest and individual abilities of students. The share of core curriculum optional education at the upper secondary level is between 45% and 80% of the classes. Academic time for core curriculum optional education at upper secondary is used for general, specialized or vocational training. Compulsory teaching hours include compulsory and core curriculum optional education. Elective hours are allotted to subjects according to every school's opportunities and students' choices.

A new educational law on pre-school and school education entered into force in Bulgaria on 1 August 2016. It gives a new structure to the Bulgarian educational system:

- general education (grades 1-7):
  - primary education (grades 1-4)
  - lower-secondary education (grades 5-7)
- upper-secondary education (grades 8-12):
  - first stage of upper-secondary education (grades 8-10)
  - second stage of upper-secondary education (grades 11-12).

Secondary school students who have already started their education before 2016 are going to graduate by the previous law.

According to both laws, students study compulsory chemistry in 7th, 8th, 9th and 10th grade and optionally at 11th and 12th (advanced courses), depending on the direction of studies chosen by the students. Secondary school curricula are centralized, and thus all Bulgarian schools must follow a particular sequence of chemistry courses and use the same educational materials authorized by the Ministry of Education and Science. Chemistry core curriculum under the previous law consisted of:

- Classification of substances and nomenclature;
- Structure and characteristics of substances;
- Application of substances;

- Chemical processes;
- Experiment and research.

The curriculum contains topics from the following chemistry sub-disciplines – Inorganic, Organic, Theoretical, Analytical, Physical and Biochemical. It should be noted that students from 9^{th} to 12^{th} grade will still follow this curriculum. Chemistry curriculum follows a macroscopic to microscopic approach. This approach refers to instructional methods that use examples from the real world to introduce chemistry topics, followed by microscopic explanations using two-dimensional drawings of dots and circles to represent atoms, ions, and molecules (Gabel, 1999). The curriculum, both in core and advanced courses, emphasizes a linear development of chemical concepts. This refers to instructional methods that start subjects that introduce first basic theoretical concepts of atomic theory and bonding on the microscopic level and proceed to subjects focusing on the macroscopic level (Gabel, 1999). Students must know to represents chemical equations and to develop the ability to solve algorithmic chemistry exercises and problems.

Methodology

The methodology section consists of three parts - the instrument, the translation and adaptation and participants and procedure.

The instrument

Students' motivation toward science learning questionnaire (SMTSL) consists of 35 items on a 5-point Likert-type scale (Tuan et. al, 2005). The response categories are "strong disagree", "disagree", "no opinion", "agree", and "strong agree". The BG SMTSL consists of the original six scales with items from SMTSL questionnaire (Tuan et. al, 2005). The scales of the questionnaire are self-efficacy, active learning strategies, chemistry learning value, performance goal, achievement goal and learning environment stimulation. Every scale consists of different items. The scales are adapted to chemistry learning. In the following, we define each factor in the questionnaire (Tuan et. al, 2005):

1. *Self-efficacy:* Bandura's (1986) definition of self-efficacy is people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performance (p. 391). This means that students believe in their own ability to perform well in chemistry learning tasks.
2. *Active learning strategies:* Students take an active role in chemistry learning by constructing new knowledge based on their previous understanding.
3. *Chemistry learning value:* The value of chemistry learning is a complex process and includes forming different skills and competencies in students – to let students acquire problem-solving competency, experience inquiry, stimulate their own thinking, and find the relevance of chemistry to daily life. If they can perceive these important values, they will be motivated to learn chemistry. In chemistry, learning values are integrated with the inquiry and problem-solving features of science learning.
4. *Performance goal*: The students' goals in chemistry learning are to compete with their classmates and get attention form the other students and their teacher.

5. *Achievement goal:* Students feel satisfaction as they increase their competence and achievement during chemistry learning.
6. *Learning environment stimulation:* In the class, the learning environment surrounding the students, such as the curriculum, the teachers' methods, and pupil interaction, influenced students' motivation in chemistry learning.

The Cronbach's alpha reliability coefficient of the complete original SMTSL is 0.89, which means that at least 93% of the total score variance is due to true score variance.

The Translation and Adaptation

The Bulgarian version of students' motivation toward chemistry learning questionnaire (BG SMTCLQ) is the chemistry specific students' motivation toward science learning questionnaire (SMTSL) version in which the word "chemistry" is substituted for the word "science". The SMTSL is selected for the following reasons: (a) it is the only scale that combines the constructivist learning and motivation theories; (b) it is based on a widely accepted theoretical formulation of motivational construct; (c) it functionalizes the motivational construct with a range of indicators; (d) it is validated and applied on secondary students, and (e) it demonstrates various psychometric properties that render it acceptable.

The adaptation and translation process is made following International Test Commission (ITC) guidelines for test translation and adaptation (Hamleton, 2001). The authors of the study respect the copyright law and agreements that exist for the original SMTSL questionnaire. They asked the intellectual property owner of SMTSL for permission before starting a test adaptation.

A team of three translators worked independently to translate and adapt the questionnaire. One of them is a chemistry teacher who teaches the subject in English in a language school. The second is the first author of this study who has a masters degree in chemistry and a masters degree in English literature. The third translator is a professional translator. All of them have knowledge of both languages, knowledge of the cultures, knowledge of the subject matter and at least general knowledge of testing principals. Every translation was done individually and then the inconsistencies were compared. Afterwards, the translated questionnaire was back translated into English by another English teacher who has no knowledge of the questionnaire, in order to check the consistency with the translated questionnaire and the original one.

The purpose was to find out whether there is any ambiguity in the items and determine conceptual and cultural equivalence. Additionally, to the final stage of the adaptation and in order to check the face and content validity, the translated questionnaire was administrated to 75 secondary school students. Based on feedback, the questionnaire was revised and minor changes were made with consensus. The team of translators attempted to find a balance between a literal and a cultural-specific translation so that the translation and adaptation of items are appropriate for Bulgarian secondary school students. Hence, the questionnaire in the target language was finalized and subjected to further testing of psychometric properties.

Participants and procedure

The Bulgarian version of the questionnaire was administrated to 250 upper secondary and vocational students from eight schools in seven cities in Bulgaria. The upper secondary students were 210 and the vocational students were 40. From them, 148 are female students and 89 are male students. Only 237 surveys were valid for analysis. 14.78% of the sample are ninth graders; 48.52% are tenth graders; 24.90% are eleventh graders and the rest (11.80%) are twelfth graders. Only 28 of them optionally studied chemistry. The questionnaire was administered to students in their chemistry classes by their chemistry teachers in the period April – May of school year 2017-2018. Students were informed about the study and they consented to participate. Their responses were assessed using a Likert-type scale ranging from 1 (strong disagree) to 5 (strong agree).

The data collected from the upper secondary and vocational students was analyzed. Students' responses were tallied according to their response (for example: strong disagree = 1 or strong agree = 5). The performance goal items were reverse coded; therefore, the items connected with the performance goals of the students were recoded (for example if a student's response is 1, it is tallied as a 5). The maximum possible score is 185 and the minimum is 35.

The reliability of the BG SMTCLQ was analyzed by internal consistency assessed via Cronbach's alpha. For educational studies, the suggested alpha value is at least 0.70 and preferably higher (Fraenkel & Wallen, 2003).

Data Analysis

The data collected from 237 upper secondary students in eight Bulgarian schools were used to examine the reliability and discriminate validity of the Bulgarian version of the questionnaire. The percentage of variance as a measure of dispersion of the variable refers to the homogeneity of scores in each scale and in the all 35 items in the questionnaire. It ranges from 15.7% to 25.3% for different scales, with the total variance accounted for being 14.7 (Table 1). The lowest variability of the six scales is observed within the *Active learning strategies* scale. The values of CV do not exceed 30%, and thus indicate that the students' scores are not very spread out from the mean or from one another. For the Bulgarian revised version of SMTCLQ, two more indices of the reliability and validity were calculated: the Cronbach alpha reliability coefficient and discriminant validity index presented by the mean correlation of each scale with the other five scales. The data in Table 1 show that the internal consistency (Cronbach alpha) of the six scales ranges from 0.69 to 0.86 with the individual as the unit of analysis. For all 35 items of the BG SMTCLQ, the internal consistency reliability is as high as 0.91. These results help us conclude that the internal consistency is satisfactory for all scales as well as for the revised Bulgarian version of the SMTCLQ as a whole.

The discriminant validity is estimated by the mean correlation of a scale with other scales. It ranges from -0.12 to 0.23. These results suggest that the scales in the BG SMTCLQ assess distinct constructs with a small degree of overlap. The negative index for *Performance goal* distinguishes clearly this scale from other five scales. It is worth noting that the discriminative validity of *Performance goal* is also the lowest compared to the other scales in the Tuan et al. (2005) study of SMTCLQ validation.

Table 1. *Internal Consistency (Cronbach alpha coefficient) and Discriminate Validity (mean correlation of with other scales) for the BG SMTSL questionnaire (n = 237)*

Scale	Item number	Mean	CV*, %	Standard deviation	Cronbach alpha	Mean correlation with other scales
BG SMTCLQ	35	124.9	14.7	18.4	0.91	
Self-efficacy	7	24.1	25.3	6.1	0.86	0.23
Active learning strategies	8	31.2	15.7	4.9	0.81	0.22
Chemistry learning value	5	17.7	22.0	3.9	0.80	0.22
Performance goal	4	13.6	23.5	3.2	0.71	-0.12
Achievement goal	5	17.9	20.1	3.6	0.69	0.18
Learning environment stimulation	6	20.0	24,5	4.9	0.82	0.20

* CV is the coefficient of variation

Conclusion

The importance of motivation in school education is worldwide well documented. Students' motivation is important element for chemistry education because it is highly correlated with students' success in chemistry learning. Although an enormous amount has been published about motivation of students in science education, only a few of them involved quantities research in the field of chemistry and any in Bulgaria. The present study goal was to adapt the questionnaire that measures students' motivation towards science learning (SMTSL) for application in a different language (Bulgarian) stressing particular learning in chemistry. Overall, the results suggest that the BG version of SMTCLQ is reliable and valid. All subscales of the adapted questionnaire had acceptable reliability and its hypothesized factorial structure was confirmed. The low correlations between scales support the instrument's internal construct validity. Furthermore, the results show that the BG version of SMTCLQ could be used with confidence in research on students' motivation towards chemistry learning in Bulgarian secondary schools. The results are comparable and even similar to the study of the SMTCLQ (Tuan et al., 2005). Further, research about the ability of the questionnaire to differentiate between classes should be found, especially since students within a class are taught in the same learning environment by the same chemistry teacher, and therefore their motivation could differ from students in other classes.

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