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Motivation to learn Biology: Adaptation and validation of a Science Motivation Questionnaire with Slovene secondary school students

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Motivation for biology can be considered as one of the most important factors influencing the teaching and learning of biology. Thus, the main objectives of this research were to test the validity of an instrument that measures students' motivation for the subject of biology, and to determine the situational motivation of Slovenian secondary school students for learning biology. Based on 516 completed web questionnaires filled in by various secondary school students from Slovenia, we came to the following conclusions. By applying non-parametric tests, we concluded that there were certain statistical differences between genders and between students from different secondary schools and regions when it came to motivation for studying biology. First-year students are more concerned with assessing knowledge. Those from the fourth year, on the other hand, are more interested in the knowledge they have acquired rather than the grade they have achieved. They also considered knowledge in biology as important for their life and thus for their career. The factor analysis yielded a structure different from the theoretical constructs. The responses of Slovenian secondary school students formed five factors for the motivation to learn biology: (1) intrinsic motivation and personal importance, (2) anxiety about assessment tasks, (3) self-efficacy in assessments, (4) career motivation and (5) responsibility. This information could be useful for teachers and researchers to promote motivation for the discipline and subject of biology. A lack of motivation in science can hinder science and science literacy, which is necessary for responsible decision-making and behaviour and in choosing a career in science.

Keywords: biology motivation questionnaire, career motivation, extrinsic motivation, fear, intrinsic motivation, personal significance, self-efficacy

INTRODUCTION

Motivation is a crucial element in research as it provides the impetus to transform abilities into performance (McCoach et al., 2018). It is often seen as the catalyst that

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enables potential to be harnessed to achieve significant success (McCoach et al., 2018). In the context of learning, motivation is not a single construct, but rather encompasses a variety of different constructs such as ability self-concepts, task values, goals, and achievement motives (Steinmayr et al., 2019). The concept of motivation in education is complex (Eccles, & Wigfield, 2002), and learning is influenced by different types of motivation (Lee et al., 2016). Motivation is the process that challenges, directs, and controls human activity or satisfaction (Bandura et al., 2001), and in the words of Ryan and Deci (2000, p. 54), "To be motivated is to be moved to do something." Only motivated students actively participate in learning; they learn and continue learning until they reach the set learning goals (Juriševič, 2012). The occurrence of motivation in education is often hidden, and the true causes of learning cannot be observed with equal success (Krajnc, 1982). Gottfried (1990) defines learning motivation as the enjoyment of learning in school, where students are curious, persistent, and eager for new and more demanding tasks and challenges. Turner (1995), on the other hand, believes that learning motivation is synonymous with voluntarism and the self-regulation of high-level learning strategies.

German psychologist Rheinberg (Rheinberg, Vollmeyer and Rollett, 2000, in Juriševič, 2012, p. 12) explains that the influence of motivation on learning manifests itself at three levels: (1) At the level of the time the student devotes to learning and learning tasks; (2) At the level of the form or nature of learning activities, which includes the balance of effort a learner invests in learning, on the one hand, and the use of learning strategies that stimulate the learner to learn and enable the learner to achieve the learning goals effectively, on the other; (3) At the level of the learner's functional mood, which refers to the learner's optimal psychological state when learning. Research into motivation goes beyond its immediate effects on the learning process. One prominent area of investigation focuses on the influence of gender on achievement motivation, attracting the attention of psychologists and educational researchers, as Meece et al. (2009) point out. Various theories suggest that motivational beliefs and behaviors of both girls and boys often conform to traditional gender role stereotypes. Boys tend to express stronger abilities and interests in math and science, while girls show more confidence and interest in language and writing skills (Meece et al., 2009). Recent research by Stolk et al. (2021) looks at the complex relationships between course pedagogy, gender, and situational motivations, particularly in STEM courses. Their findings show notable differences in lecture-based learning environments, with women reporting lower self-determined motivation compared to men. However, in courses that include active learning methods, the motivation profiles of both genders are similar and more positive overall (Stolk et al., 2021). Zaccone and Pedrini (2019) examine the moderating role of gender in the complex interplay between student motivation and learning effectiveness and provide valuable insights. While these studies overall provide a comprehensive understanding of the nuanced relationship between motivation and gender, they emphasize the need to acknowledge gender differences in the formulation of motivational strategies in educational settings. It is evident that adapting educational approaches to these differences is crucial. By further exploring the multi-layered dynamics between motivation and gender, researchers can contribute to the development of more targeted and effective strategies to promote success in diverse groups of students.

Motivation plays a decisive role in the learning of biology, as in any other subject. It is the driving force that encourages students to engage with the material, persevere in the face of challenges and ultimately improve their understanding and performance (Grossmann et al., 2023; Howard et al., 2021). By understanding and addressing the factors that influence motivation, educators can create a learning environment that promotes engagement, persistence, and achievement. Intrinsic motivation for learning has been found to be significantly positively related to the perceived value of research activity, which in turn predicts learning effort and productivity (Stupnisky et al., 2023). The desire to face challenges in solving unsolved problems, the desire to earn an educational degree, and the desire to experience the intellectual pleasure of creative work are some of the motivational factors for choosing to learn.

There are several factors that can influence a student’s motivation to learn biology. Students are often more motivated to learn when they find the subject matter interesting or relevant to their own lives (Howard et al., 2021). This can be a fascination with living organisms, an interest in how the body works, or a desire to understand the natural world. Despite the importance of science to daily life, interest in STEM subjects and the number of first-year students has declined worldwide, which has been recognized as a societal problem (Alexander et al., 2019; Guo et al., 2019; Osborne et al., 2003). Numerous initiatives, particularly in the education sector, aim to combat this trend (Potvin & Hasni, 2014). The education sector plays a key role in influencing attitudes and career aspirations through content, teaching methods and the integration of technology into STEM subjects (Ploj Virtič & Šorgo, 2016; Šorgo et al., 2018; Špernjak & Šorgo, 2020). The perceived relevance or usefulness of biology to a student’s future career or personal goals can also be a strong motivator (Howard et al., 2021). For example, students who want to become doctors or environmental scientists may be particularly motivated to learn biology. Students may be motivated by the desire to achieve certain goals, such as getting good grades, outperforming their peers, or mastering the subject matter (Howard et al., 2021). The learning environment can also have an impact on motivation. For example, a supportive and autonomy-promoting teaching style can promote self-determined motivation. This means that students feel that they are responsible for their learning, which can make the learning process more enjoyable and effective (Großmann et al., 2023). The right balance between challenge and support in the curriculum can also increase motivation. If the material is too easy, students may become bored. If it is too hard, they may become frustrated. But if it is just right, students can experience a "flow" state where they are fully engaged and enjoying the learning process (Howard et al., 2021).

In terms of supporting literature, there are numerous studies (McCoach et al., 2018; Sekhar et al., 2019; Steinmayr et al., 2019, Lai, 2011) and theories that delve into the role of motivation in learning. Educational psychologists, even as practicing educators, have long recognized the importance of motivation in learning and participation. They note that motivation is among the life- and work-related motives and drives that someone must achieve to set goals (Lai, 2011). The subject of school biology is not exempt from this rule, and the relationship between motivation and various aspects of teaching and learning biology has been confirmed in numerous studies (Glynn et al., 2009; Jeno et al., 2017; Mahler et al., 2017).

It is practically impossible to assess all the theoretical constructs derived from different motivational theories (Eccles, & Wigfield, 2002) that require the development of standardized instruments with verified validity of the measured constructs. Furthermore, such standardized instruments can be used in comparative studies that allow for replication and generalization of results (Anderson, & Maxwell, 2017; Amrhein, Trafimow, & Greenland, 2019). Therefore, between the options of developing a new instrument or testing the existing one, the second option should be preferred. After a careful review of existing instruments measuring scientific (biological) motivation (for a review, see Janštova & Šorgo, 2019), the choice fell on an instrument developed by Glynn et al. (2009). They developed the Science Motivation Questionnaire (SMQ), which can be adapted to biology by simply replacing the word science with the word biology, thus becoming the Biology Motivation Questionnaire (BMQ). The questionnaire captures the constructs of intrinsic motivation (IM), extrinsic motivation (EM), personal relevance (PR), responsibility (RE), self-efficacy (SE), and anxiety (AN). After construct validity was examined in follow-up studies, the SQM II was compiled (Glynn et al., 2009). The BMQ was chosen by the authors because of its strong theoretical background and clearly defined motivational constructs. Before recommending the use of the BMQ in school practice, it was the author's intention to examine the BMQ through exploratory and confirmatory factor analysis and adjust as necessary. In parallel with this main objective, we want to investigate the level of motivation among secondary school students of biology in Slovenia.

Theoretical Framework

The basis of the questionnaire S(B)MQ (Glynn et al., 2009) discussed is two theories. Deci and Ryan (1985) formulated a self-determination theory that distinguishes between different types of motivation: intrinsic or extrinsic motivation, and amotivation. In addition, extrinsic motivation consists of several subtypes as distinguished by Ryan and Deci (2000), who also distinguish between extrinsic control and true self-regulation. The other theory is Bandura's self-efficacy theory of motivation (Bandura, 1982), which recognizes self-efficacy as a means that influences the willingness to initiate an action and how long one engages in it.

The questionnaire BMQ by Glynn et al. (2009) has six constructs as follows.

Intrinsic motivation refers to curiosity about, and interest and enjoyment in learning biology (Glynn et al., 2011). According to the theory, intrinsic motivation due to interest, curiosity, and desire to discover leads to the pursuit of activity for satisfaction and is recognized as the preferred incentive for academic success (Ryan, & Deci, 2000).

Extrinsic motivation is seen in the influence and importance of rewards such as a good grade for students, which motivates them to continue their work. Extrinsic motives can be internalized; that is, they can be passively and even actively adopted and integrated. In the educational context, it appears that intrinsic motivation (for active exploration and learning) weakens with each advancing grade (Ryan, & Deci, 2000, p. 60), possibly because the extrinsic, tangible rewards that are prevalent in schools undermine internal motivation (Deci et al., 2001).

Self-efficacy is the feeling about one's abilities. Albert Bandura (in Woolfolk, 2002, p. 340) defines self-efficacy as "one's belief in one's ability to organize and carry out the actions necessary to achieve specific accomplishments." Belief in one's abilities influences motivation even in the planning stages of learning or other goals. If students feel a high level of self-efficacy in a particular area, they will set higher goals and not fear failure. Self-efficacy is strengthened when they attribute success to internal or controlled reasons, such as ability or effort. If they attribute success to luck or other external causes, self-efficacy is lower (Woolfolk, 2002). Many studies have found that there are statistically significant differences between boys and girls. (Glynn et al., 2009, Schumm, & Bogner, 2016; Yeoh, & Ierardi, 2015) attribute lower self-efficacy and self-determination to the male gender.

Personal relevance is described by Glynn et al., 2009 (p. 1095) as the "relevance of science learning to personal goals", such as future life and career. It has been shown that personal relevance is a direct predictor of attitude (Liberman, & Chaiken, 1996). This is believed to be is one of the most important factors in designing a science curriculum (Yager, 1989), and according to (Teppo, & Rannikmäe, 2003, p.49), "students are motivated to learn when the science content is understandable, interesting and related to their everyday lives".

Responsibility refers to self-determination in learning biology, in the sense of students' belief that they are in control of their learning (Glynn et al., 2007, p. 1090). Responsibility scores are high in engaging activities (Skelly, & Bradley, 2007).

Anxiety or fear in the instrument refers to assessment anxiety (Glynn et al., 2007, p. 1090), as a debilitating tension related to grading in science. When the level of assessment anxiety is high, it hinders students' motivation and thus their performance (Cassady, & Johnson, 2002), which can be understood as amotivation as defined by Ryan and Deci (2000). Anxiety is an emotion that is often mentioned in the context of learning. It is one of the sources of negative intrinsic motivation because it is an emotional response to a threat or perception of danger. On the other hand, many believe that moderate anxiety is the only incentive for learning. Anxiety often arises when testing or evaluating knowledge, when students are afraid of failure (Marentič Požarnik, 2000).

Even though the constructs of the S(B)M questionnaire have a theoretical background, there is always the possibility that original constructs or items from different constructs are clustered differently and form "super constructs" (Kjærnsli and Lie, 2011). Since there have been concerns about construct validity (Çetin-Dindar & Geban, 2010; Glynn et al. 200911; Janštova & Šorgo, 2019; Salta & Koulougliois, 2015; Taun et al., 2011; Velasufah & Setiawan, 2019; Yeoh & Ierardi, 2015), we also sought to evaluate the construct validity of the Slovenian version of the BMQ and conduct an analysis to find any super-constructs.

While extensive literature emphasises the importance of motivation in learning (McCoach et al., 2018; Steinmayr et al., 2019), this study seeks to make a unique contribution by validating and adapting the BMQ for Slovenian upper secondary school students. Our research questions (RQ1-RQ3) aim to explore the validity of the translated BMQ, examine the proposed structure of its constructs, and assess students' situational motivation in biology classrooms.

By answering these research questions, we aim to provide educators and researchers with a validated instrument that can improve our understanding of student motivation in biology classrooms. In addition, the insights gained from this study can inform strategies to promote STEM-related career aspirations in students to address current societal challenges related to declining interest in science (Alexander et al., 2019; Guo et al., 2019).

Following the objectives of the study, the research questions were as follows:

RQ1: Is the translated BMQ a valid instrument that measures students' motivation for biology as a subject?

RQ2: Do the constructs follow the hypothesized structure as suggested by the authors of the instrument?

RQ 3: What is the level of situational motivation of Slovenian upper secondary students for biology classes?

METHOD

The Instrument

The Science Motivation Questionnaire (SMQ) (Glynn et al., 2009) was translated and retranslated from the Slovenian language by educational researchers proficient in both languages. The original version was tested for clarity by a group of preservice biology teachers. The difference between the Science Motivation Questionnaire and the BMQ is the main statement, in which the word science was replaced by the word biology, as previously proposed by Glynn et al. (2009) and applied by Janštova and Šorgo (2019) on a population of Czech high school students. Students answered the assumptions in the context of "When I am in a (high) school biology course…". Responses were measured using a 7-point scale Likert Scale. The scale ranges from 1 - definitely disagree, to 7 - definitely agree, with no gradations between the extremes. The scale differed from that used by Glynn et al. (2007) and was changed from never (1), rarely (2), sometimes (3), usually (4), and always (5). The reason for this change was the planned statistical analyses, where longer response scales are preferred to shorter ones, and normality of distribution is expected (Taherdoost, 2019). All items of the component AN (fear or anxiety) are reversed on the questionnaire and were recalculated before inclusion in analyses. The coefficient of Cronbach's alpha (α) for the translated version of the whole Biology Motivation Questionnaire is 0.91, which means that the whole questionnaire has good reliability. The alphas of the subscales are shown in the Results section in Table 3 and Table 4. The items of six subscales can be found in Table 1, and the text of all items can be found in Table 2.

Table 1
The six subscales (constructs) of BMQ as proposed by Glynn et al. (2009)

Six subscales	Code	Items
Intrinsic motivation	IM	1, 14, 19, 24, 27
Extrinsic motivation	EM	3, 7, 13, 15, 28
Personal relevance	PR	2, 20, 22, 29, 30
Responsibility	RE	5, 8, 9, 17, 23
Self-efficacy	SE	10, 18, 21, 25, 26
Anxiety	AN	4, 6, 11, 12, 16

Sample and Sampling

The survey was conducted using the open-source online application 1KA (https://www.1ka.si/) from March 15, 2017, to March 29, 2017. We sent Slovenian high school biology teachers an invitation and a request to distribute the survey to their students. We sent them a link to the survey and asked them to forward the link to the students in their school. We obtained teachers' email addresses from publicly available websites.

The sample consisted of 516 students (72% girls and 28% boys) from several Slovenian upper secondary schools, who participated anonymously. 94% of respondents were from general secondary schools, and only 6% of respondents were from vocational secondary schools. Students from all four years participated in the survey (from 1st year 23%, from 2nd year 38%, from 3rd year 27% and from 4th year).

Statistical Procedures

After an initial review of the data, exclusion was applied to respondents who provided answers with unacceptable amounts of missing data. These data sets were used in descriptive and inferential statistical procedures. In the SEM (Structural Equation Modelling) analyses, only datasets without missing data were included, a procedure which allows application of modification indexes as provided by a computer program (Kline, 210; Byrne, 2016). The reliability of the questionnaire and its subscales was calculated as Cronbach's alpha (see Tables 3 and 4). The procedures of descriptive (frequencies, mode, median, mean, and Standard Deviation) and inferential statistics (Mann-Whitney U test and Kruskall-Wallis test) were used to describe and examine differences between subgroups of the sample (gender, school type, age). Effect sizes were calculated by use of the Psychometrica online engine (Lenhard, & Lenhard, 2016). Exploratory Factor Analysis was the choice for analysing the factor structure of the questionnaire. By using Principal Component analysis with Direct Oblimin rotation, two pieces of information were sought. The first was related to the unidimensionality of each subscale (construct), and the second was applied to the whole data set to reveal possible differences between the theoretically predicted components and the component structure of the sample. Parallel analysis was used to uncover several components that should be retained (Patil, 2017).

To examine latent variables (constructs) and the relationships between them, CFA with Structural Equation Modelling (SEM) was the choice. The procedures used and improvements to the hypothesized models follow procedures and cut-off fit indices as suggested by Byrne (2016). The collected data were statistically processed using the program IBM SPSS Statistics 27, and AMOS 27.

FINDINGS

The motivation level of high school students for biology classes can be seen in Table 2. The items are sorted by decreasing arithmetic mean by each six subscales.

Table 2
Descriptive statistics for BMQ for Slovenian students

Code	Statement	Med	Mean	SD
Anxiety (AN)				
AN4	I am nervous about how I will do in biology assessments. *	6	5.24	1.72
AN16	I hate taking biology assessments.*	4	4.40	1.85
AN6	I become anxious when it is time to sit a biology assessment.*	4	3.97	1.91
AN11	I worry about failing biology assessments.*	3	3.67	2.30
AN12	I am concerned that the other students are better at biology.	3	3.17	1.82
Extrinsic motivation (EM)				
EM7	Achieving a good biology grade (Achieved / Merit / Excellence) is important to me.	6	5.72	1.39
EM13	I think about how biology will affect my overall subject or certificate endorsement.	5	4.95	1.86
EM15	I think about how learning biology can help my career.	5	4.77	1.84
EM28	I think about how learning biology can help me get a good job.	5	4.66	1.76
EM3	I like to do better than the other students in biology assessments.	5	4.65	1.82
Intrinsic motivation (IM)				
IM27	Understanding biology gives me a sense of accomplishment.	6	5.29	1.60
IM19	I find learning biology interesting.	5	4.83	1.81
IM1	I enjoy learning biology.	5	4.64	1.76
IM24	I like biology that challenges me.	5	4.62	1.79
IM14	The biology I learn is more important to me than the grades I receive.	5	4.52	1.80
Personal relevance (PR)				
PR20	The biology I learn is relevant to my life.	5	4.91	1.65
PR29	I think about how the biology I learn will be helpful to me.	5	4.88	1.59
PR22	The biology I learn has practical value for me.	5	4.82	1.62
PR30	I think about how I will use the biology I learn.	5	4.81	1.72
PR2	The biology I learn relates to my personal goals.	5	4.20	1.75
Responsibility (RE)				
RE23	I prepare well for the biology assessments (both intrinsic and extrinsic).	5	4.91	1.49
RE5	If I am having trouble learning biology, I try to figure out why.	5	4.85	1.74
RE8	I put enough effort into learning biology.	5	4.84	1.59
RE9	I use strategies that ensure I learn biology well.	4	4.04	1.70
RE17	It is my fault if I do not understand the biology ideas.	4	4.02	1.72
Self-efficacy (SE)				
SE26	I believe I can earn 'excellence' grades in the biology course.	6	5.50	1.61
SE21	I believe I can master the knowledge and skills in the biology course.	6	5.30	1.55
SE18	I am confident I will do well on the written and practical biology assessments.	5	5.25	1.42
SE25	I am confident I will do well in the biology assessments.	5	5.09	1.61
SE10	I expect to do as well as or better than other students in a biology course.	5	5.04	1.63

Table 2 provides a comprehensive overview of the students' responses, with the items within each subscale sorted by decreasing mean value.

Item from extrinsic motivation (EM) is mentioned first: *"Achieving a good biology grade is important to me."* This is followed by two self-efficacy (SE) statements. They indicate that Slovenian students believe that they are very self-efficacious, that they can achieve good grades in Biology, and that they have mastered the knowledge and skills of the subject Biology. The first item of Intrinsic motivation (IM) appears only in the fourth place.

There are three anxiety (AN) items which show only moderate worry and anxiety before grading. The entire questionnaire shows that students are not worried about grading in biology, are not anxious about exams in biology, and rate themselves as self-efficacious in studying biology. All five self-efficacy (SE) statements have an arithmetic mean between 5.04 and 5.50, which means that students agree that they are self-efficacious in biology studies and believe in themselves, their knowledge, and their abilities. Based on the results, it is also important for students to have a good grade in Biology.

From the results, it can be claimed that Slovenian students consider themselves to be self-confident, self-efficacious, and, above all, extrinsically motivated for the subject of Biology. Intrinsic motivation is stated as a theoretical priority for the subject of Biology, but it comes behind extrinsic motivation.

Using nonparametric tests, we found that there were statistically significant sex differences at the $p < .05$ level for statements AN4, AN11, AN12, EM7, EM13, EM28, IM27, PR20, IM19, RE8, RE9, RE23, SE18, SE21, and SE25. However, when we calculated the effect sizes, we found that these gender differences were almost irrelevant ($r < .2$), except for assertion PR20, for which $r > .2$ holds. For assertion PR20 ($p < 0.05$ and $r = .21$), we found that girls were more likely to agree that the material they learn in biology class is important for their lives.

Motivation for biology classes was also tested as a function of school type and year of attendance. We found that there were statistically significant differences between general upper secondary school students and other high school students. Emphasising ST4 ($p < 0.05$ and $r = .21$), we found that students from general education high schools were more worried about how they would perform in the Biology grading.

Reliability and Dimensionality of the Theoretically Predicted Components

The full BMQ has high reliability since the value of Cronbach's coefficient alpha (α) is .91. Table 3 shows the results of Cronbach's alpha coefficient for each construct according to Glynn et al. (2009). From the α coefficients, it can be seen that four constructs (subscales) are reasonably reliable, with a value of $\alpha > .70$. Below the thresholds were extrinsic motivation and responsibility for learning biology, and even there it was possible to raise the alphas to acceptable levels by deleting one item in each construct.

The unidimensionality of the theoretically predicted constructs was tested by PCA with Direct Oblimin rotation. The results are presented in Table 3 and Table 4.

Table 3
Reliability and dimensionality of the theoretically predicted and unidimensional components (constructs)

	Intrinsic motivation	Personal Relevance	Self-efficacy
Loading items	IM19, IM1, IM24, IM1, IM27	PR22, PR20, PR30, PR29, PR2	SE18, SE25, SE26, SE21, SE10
Cronbach's α	.87	.87	.85
Explained Variance (%)	65.72	66.62	63.10
Eigenvalue	3.29	3.33	3.15

Table 4
Reliability and dimensionality of theoretically predicted components and components extracted by PCA

	Extrinsic Motivation		Responsibility		Anxiety	
Component name	Job and Career	Grading and Assessment	Problem-Solving	Self-Accusation	Worry	Hate
Loading items	EM28, EM15	EM7, EM13, EM3	RE8, RE23, RE9, RE5	RE17	AN12, AN4, AN11	AN6, AN16
Cronbach's α	.80	.54	.65	/	.64	.78
Explained Variance (%)	45.64	20.92	47.62	20.65	47.45	21.31
Eigenvalue	2.28	1.05	2.38	1.03	2.37	1.07

In Table 3, it can be seen that Intrinsic Motivation (IM); Personal Relevance (PR), and Self-Efficacy (SE) all have features that can be included in the CFA (α >.7; unidimensionality), which cannot be said of Extrinsic Motivation (EM), Responsibility (RE) and Anxiety (AN). All three dimensions are split into two principal components. We gave these components new names and find that they are not suitable to be included in SEM (low alphas and less than three items in a construct). Nevertheless, we constructed Model 1 based on theoretically driven constructs as suggested by Glynn et al. (2009).

CFA of Concurrent Models

Having applied SEM analysis to the hypothesized Model 1 based on six subscales following the constructs as proposed by Glynn et al. (2009), and to Model 2 based on PCA analysis of each construct as shown in Tables 3 and 4, we found that neither model was an acceptable fit to the data. The models and path coefficients are not presented in the paper.

Table 5
Fit indices of Model 1 and Model 2.

Model	NPAR	χ2	df	χ2 /df	IFI	CFI	RMSEA
Threshold values				< 3	> .90	> .90	< .07
Model 1	75	2322.91	390	5.97	.77	.77	.10
Model 2	97	1724.97	368	4.69	.84	.84	.09

Table 5 indicates that neither model based on constructs as shown in Table 3 and Table 4 fits at the suggested values of chosen indices. An additional warning sign was the correlations between constructs. Some correlations are too high (*r* > .8) or too low (*r* < .2). Therefore, we abandoned both models and proceeded with Principal Component Analysis of the entire set to reveal hidden latent variables.

Principal Component Analysis of the Entire Set

In the following procedure, we performed PCA on the whole set of 30 items to find latent variables not predicted by the original authors. The suitability of the matrix to perform factor analysis was tested by KMO (0.93) and Bartlett's test ($p < .001$). PCA identified 5 components with eigenvalue > 1, explaining 61.56 % of the variance. Some of the resulting constructs from the described analysis do not follow the theoretical considerations of the authors (Glynn et al., 2009) of the SMQ. The results of PCA are presented in Table 6.

Table 6
Components of motivation as revealed by PCA analysis of BMQ

Cronbach's alpha	.91
Component 1	Personal relevance and intrinsic motivation
Model code	PRIM
claims	IM19, IM1, PR2, AN16, PR22, IM14, PR20, AN6, IM24, RE5
Explained variance (%)	35.44
Eigenvalue	10.35
Cronbach's alpha	.78
Component 2	Fear of (anxiety about) assessment
Model code	ANEM
claims	AN12, AN4, AN11, EM13, AN6
Explained variance (%)	10.77
Eigenvalue	3.08
Cronbach's alpha	.72
Component 3	Self-efficacy and evaluation
Model code	SEEM
claims	SE18, SE25, EM3, SE10, SE26, EM7, SE21
Explained variance (%)	6.82
Eigenvalue	2.16
Cronbach's alpha	.86
Component 4	career motivation
Model code	PREM
claims	EM28, PR29, EM15, PR30
Explained variance (%)	4.40
Eigenvalue	1.35
Cronbach's alpha	0.89
Component 5	responsibility
Model code	RE
claims	RE8, RE9, RE23, RE17
Explained variance (%)	4.13
Eigenvalue	1.26
Cronbach's alpha	.59

Table 6 shows that the first principal component explains a variance of 35.44% (α = .78). The principal component of the construct personal relevance and intrinsic motivation (PRIM) consists of the assumption that students want to learn biology for pleasure and to fulfil their personal goals, that the material has practical value for them, but that they do not like assessment because the knowledge they learn is more important than the grades they acquire. This also includes the assumption that if they have difficulty in learning biology, they want to discover the cause. The second principal component combines four anxiety items accompanied by an extrinsic item on grading (ANEM) and explains 10.77% of the variance (α = .72). It includes statements about worry and anxiety in assessing knowledge in biology as a relevant component. The third principal component (SEEM) explains 6.82% of the variance (Cronbach's coefficient alpha α = .86). The assertions in this component refer to students' conviction that the biology exam will be successful, belief that they will get very good grades, and confidence that they have mastered the skills of the subject biology. The assertions refer to self-efficacy in assessing knowledge in the subject of biology. It is noteworthy to mention that all self-efficacy items are clustered in one component. The fourth principal component (PREM) explains 4.40% of the variance (α = .89). The assertions in this component relate to how students can learn biology well and how they will apply the biology knowledge they have learned. The fifth principal component (RE) explains 4.13% of the variance (α = .59). It involves the assumption that students put enough effort and strategies into learning biology to study more efficiently to be well prepared for the exam, and that it is their fault if they do not understand the biology content. Therefore, motivation to learn biology can be considered as several dimensions which are interwoven and form five components only loosely following the theoretically predicted components.

CFA of Models Based on New Components as Fevealed from PCA

The proposed Model 3 based on five latent variables (PRIM, ANEM, SEEM, PREM, RE) resulted from PCA of 30 all original variables (Table 6, Figure 1). Fit indices of the hypothesized model were below the thresholds (Table 7), and some correlations were out of the range (Figure 1). Therefore, in Model 4, we deleted the latent variable ANEM, since it had very low correlations and disturbed the indices of the fit model Byrne (2016).

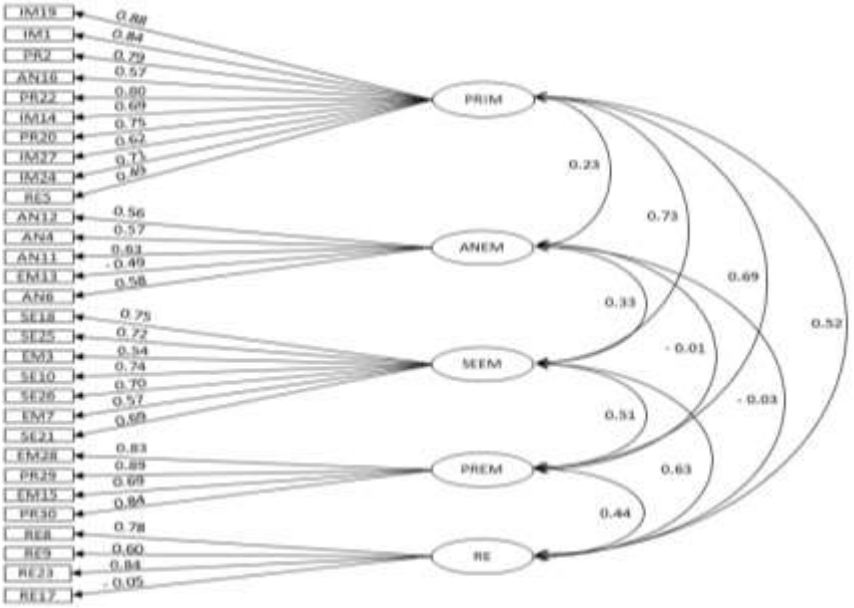

Figure 1
Model 3

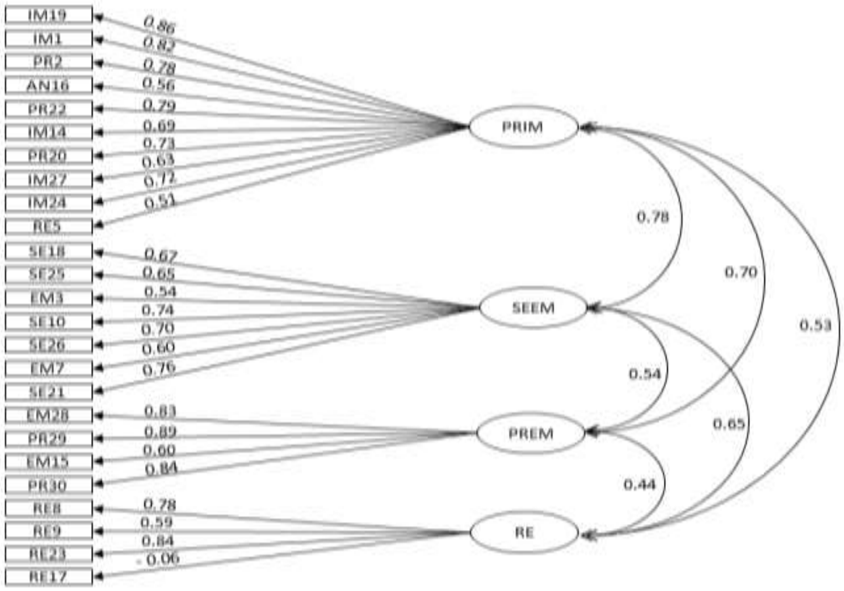

Figure 2
Final model (Model 4) based on principal components extracted by PCA analysis of 30 items

Table 7
Fit indices of hypothesized Model 3 and final Model 4 based on new components as revealed from PCA

Model	NPAR	χ2	df	χ2 /df	IFI	CFI	RMSEA
Threshold values				< 3	> .90	> .90	< .07
(Model 3)	70	1936.1	395	4.9	.82	.81	.09
Final model (Model 4)	60	925.1	265	3.5	.91	.91	.07

From the correlations presented in Figure 2 and the fit indices (Table 2) the final Model can be recognized as appropriate to explain motivation of Slovenian upper secondary school students toward Biology. Clearly, anxiety and fear are not the main drivers of their feelings about Biology.

DISCUSION

Comparing the results of the PCA analysis of BMQ with the original study by Glynn et al., (2019), we find that the Slovenian study (the current study) and research results from other countries (Janštova & Šorgo, 2019; Velasufah & Setivan, 2019; Salta & Koulougliotis, 2015; Çetin-Dindar & Geban, 2010; Bryan, 2009; Tuan, Chin & Shieh, 2005) component structure does not follow the proposed six theoretical constructs (Intrinsic Motivation, Extrinsic Motivation, Personal Relevance, Responsibility, Self-Efficacy; Anxiety) as proposed by Glynn, Taasoobshirazi and Brickman (2009). These results cannot be considered a surprise, since follow-up studies by Glynn et al. (2009) revealed component structures differing from those theoretically proposed. The best match can be found in findings published in the Czech version (Janštova & Šorgo, 2019), which shows a mixture of motivation types. These differences could be the result of different samples, because in a recent study and in the one by Janštova and Šorgo (2019), the populations differ from those in Glynn et al., (2009). In both studies, the sample comprised high school students, among whom the pressure for grades might be lower. Additionally, in both countries, enrolment in secondary schools is not connected with a heavy financial load, which can be the case with college students.

From the factor analysis results, it emerges that intrinsic motivation Slovenian upper secondary school students for biology classes explains 65.72% of the variance. Intrinsic motivation summarizes the views of students who find learning biology interesting, enjoy learning, and love the challenge of learning. This includes students who value knowledge more than the grade they achieve. Understanding biology gives these students a sense of accomplishment. Extrinsic motivation is explained by two components: career motivation, and motivation to value knowledge. Career motivation summarizes the views of students who believe that knowledge of biology will help them to obtain a good job and an acceptable career. Another component of extrinsic motivation is students who care about excellent grades and want to be better than others. Research shows that Slovenian students are extrinsically motivated to study biology. Personal relevance integrates the views of students who believe that the knowledge they have learned is very important to measure whether what they have learned is consistent with their personal goals. Responsibility is explained by two components: the first is called problem-solving motivation, and the second is called despair. Problem-solving motivation unifies the views of students who try hard to learn biology and use strategies to study more efficiently. Desperation unites those students who think that they are at fault if they do not understand the content of biology. Self-efficacy unifies the position of students who have mastered the skills of the subject and believe that they will be successful when knowledge is assessed. Anxiety is explained by two components, which we call worry and hate. Worry unites students who are concerned about how they will perform on knowledge assessments. They are also worried about receiving a negative evaluation or allowing others to be better than themselves. Hate unifies the views of students who dislike knowledge assessment because it makes them uncomfortable.

Based on the results, we established the importance of having the highest percentage of students receiving an honest grade on knowledge assessment in biology. Krajnc (1982) writes that assessments act as a motivating factor, especially during class time. Other studies also show that extrinsic motivation is superior to intrinsic motivation (Taun, Chin and Shieh, 2011; Yeoh and Ierardi, 2015); students from Turkey, on the other hand, show higher intrinsic motivation (Çetin-Dindar & Geban, 2010). The goal of such learning is not to know and master elements of subject, but a certain consequence that comes from the external environment. Extrinsically motivated students strive for good grades, praise, or avoidance of punishment (Marentič Požarnik, 2000). This may not be the case for Czech students. Czech students (Janštova & Šorgo, 2019) most often agree with the statement, "I am nervous about how I'll do in the biology exams." They are also more likely to use strategies that enable them to study more efficiently in biology. They also more often like challenges and believe in success. For Czech students, assessment is not as important as challenges in the biology subject.

CONCLUSIONS

The analysis of the Biology Motivation Questionnaire (BMQ) in the Slovenian study deviates from the theoretical constructs of Glynn and colleagues (2009) and is consistent with previous research showing differences in component structures. The dominant factor, intrinsic motivation, explains 65.72% of the variance, suggesting that students find biology inherently interesting and value knowledge over grades. Slovenian students exhibit remarkable extrinsic motivation, with career and achievement motivations at the forefront. Personal relevance emphasizes the importance students place on aligning the knowledge they learn with their personal goals. Responsibility motivation includes commitment to effective learning strategies and self-responsibility for comprehension problems. Self-efficacy represents mastery of subject knowledge and confidence in successful knowledge assessment. Anxiety, which includes worry and aversion, reflects concern about performance, negative evaluation, and discomfort with grades.

Recognizing the motivational effect of assessment, especially in the classroom, highlights the importance of fair grading in biology knowledge assessment. Individualized approaches in which teaching methods are tailored to different intrinsic and extrinsic motivational factors can improve engagement and learning outcomes in biology classrooms. It is important to consider cultural nuances and personal motivations when developing effective teaching strategies.

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