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Construction and validation of the physical science learning motivation scale among Moroccan middle school students

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Abstract

This paper presents two studies concerning developing and validating an Arabic version of a scale that measures motivation toward learning physical science in Moroccan middle school students. The scale is based on the self-determination theory (Deci & Ryan, 1985). It comprises five dimensions: intrinsic motivation, three forms of extrinsic motivation (identified regulation, introjected regulation, and external regulation), and amotivation. The exploratory factor analysis (study 1) was conducted on a sample of 144 students, and the confirmatory factor analysis (study 2) was performed on another sample of 404 students. The results of the exploratory and confirmatory factor analyses support a five-factor structure. The results also reveal that the scale and five factors have satisfactory internal consistency indices. Moreover, the construct validity is supported by correlations between the five factors that comprise the scale. All the results thus support the psychometric qualities of the physical science learning motivation scale.

Keywords: motivation, scale, physical science, psychometric qualities, students

INTRODUCTION

In the field of learning, motivation plays an important role in the initiation or orientation of behavior. The desire for knowledge is a multiform process (psychological, cultural, and biological). It leads the learner to give meaning to what they learn, increasing their motivation (Cuq, 2003). Motivation is an internal force whose determinants can be internal or external. For example, the learner may be rewarded for motivating him to learn. However, the reward does not characterize the driving force behind the learner's behavior. But this reward must affect the learner to become a force that will guide his behavior (Lieury & Fenouillet, 2010). In addition, motivation encourages spending the energy needed to achieve goals regularly or frequently performing tasks to achieve one or more goals (Roussel, 2000).

From a socio-cognitive point of view, motivation represents "a dynamic state with its origins in students' perceptions of themselves and of their environment, which incites them to choose an activity, engage in it, and persevere in order to reach a goal" (Viau, 1994). In addition, student performance can be partly linked to student engagement and motivation. A committed and motivated student tends to put in more effort, which is likely to positively affect academic performance (PNEA, 2016).

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Contribution to the literature

- This work explores the validity and reliability of a multidimensional scale that measures students' motivation to learn physical science in the Moroccan context considering self-determination theory.
- The current analysis focuses on the physical science learning motivation scale (PSLMS) using exploratory factor analysis and confirmatory factor analysis (CFA).
- This research will enable researchers to understand the motivational profile of students in the Arab context and to conduct further studies on the antecedents and consequences of motivation in the context of learning the physical sciences.

The concept of motivation has attracted the attention of many researchers in the field of education (Barkoukis et al., 2008; Carbonneau et al., 2012; Cokley et al., 2001; Grouzet et al., 2006; Legault et al., 2006; Ryan & Connell, 1989; Vallerand et al., 1989, 1992). The work on motivation to learn science, specifically physical science, is limited compared to the amount of work done on motivation in education. Motivation to learn science is seen as students' active engagement in science tasks to understand science better (Lee & Brophy, 1996), which encourages students to conceptualize their understanding of science (Pronovost et al., 2017). According to Bryan et al (2011), motivation to learn science is an internal state that awakens, directs, and supports science learning. Students motivated to learn science pursue goals such as getting good grades and moving toward science careers (Pronovost et al., 2017).

In the Moroccan education system, the difficulties frequently encountered by students in acquiring knowledge of the sciences, particularly the physical sciences, present significant challenges for teachers (Nasser et al., 2017). At the same time, students' lack of interest in the physical sciences is also a major challenge, requiring awareness campaigns and training to help middle school teachers understand the importance of motivational factors in getting students interested in learning the physical sciences (Ouasri & Bouatlaoui, 2019).

Given the importance of teaching physical science in middle school, it seems important to understand what motivates students to learn physical science. To our knowledge, no investigative tools in Arabic allow us to measure the motivation to learn physical sciences among middle school students in Morocco. Therefore, the present research aims to develop, translate, and validate an Arabic version of a multidimensional motivation scale to learn physical science based on self-determination theory (Deci & Ryan, 1985).

THEORETICAL FRAMEWORK

Definition of Motivation

Etymologically, the word "motivation" comes from the Latin "movere", which means to move, to move around, which "confirms its primary virtue: the beginning and source of all movement" (Vianin, 2006). In a broader sense, the concept of motivation is used in psychology to consider the factors that lead to behavior; it can be defined as "a principle of forces that drive organisms to achieve a goal" (Cuq, 2003). According to Legendre (1988), "motivation is a set of desire and will that drive a person to accomplish a task or aim for a goal that corresponds to a need". For their part, Vallerand and Thill (1993), defined motivation, as follows: "the concept of motivation represents the hypothetical construct used to describe the internal and/or external forces producing the initiation, direction, intensity, and persistence of behavior ".

According to Fenouillet (2016), there are at least 101 theories dealing with motivation in many areas, such as health, work, education, and sport ..., which explains the complexity of this phenomenon. In education, motivation is one of the most studied concepts (Scallon, 1992; Vallerand et al., 1989). Therefore, different theories of motivation have been used to explain human behavior in education. Some of them can be mentioned, as follows:

1. Behaviorist theory (De Landsheere, 1979; Forget, 1993).
2. Incentive motivation theory (Forget, 1993).
3. Theory of competence (Pelletier & Vallerand, 1993).
4. Self-determination theory (Deci & Ryan, 1985; Pelletier & Vallerand, 1993; Vallerand et al., 1989).

Among these theories proposed, we will retain the one based on the self-determination theory because it suits our research objectives. This theory offers a motivational model that has proved relevant in a school context (Guay et al., 2008). It also stands out for its qualitative and multidimensional approach to motivation (Deci, 1992).

Theory of Self-Determination

According to self-determination theory (Ryan & Deci, 2000), different types of motivation explain human behavior, such as engagement in academic learning. These types of motivation are divided on a continuum according to their degree of autonomy ranging from autonomous motivation (the individual engages spontaneously, voluntarily, and without feeling constrained) to controlled motivation (the individual's engagement is mainly due to social demands that are not

internalized) (Deci & Ryan, 2000; Sarrazin & Trouilloud, 2006). Self-determination theory also suggests that an individual may show a relative lack of motivation, called amotivation. This concept is not considered part of the continuum, but it should be considered, as it also helps explain some behaviors shown by students (Leroy et al., 2013). Three main categories of motivation are described, some of which consist of different types. These categories are amotivation, extrinsic motivation, and intrinsic motivation (Berger & Rinaldi Davinroy, 2015).

Amotivation

Amotivation is a "loss of motivation" (Lieury & Fenouillet, 2010). "An individual is amotivated when he or she does not perceive a relationship between his or her actions and the results obtained" (Pelletier & Vallerand, 1993). It is motivated neither intrinsically nor extrinsically (Sarrazin & Trouilloud, 2006; Vallerand et al., 1989). Moreover, the concept of amotivation is very close to Seligman's (1975) concept of learned resignation.

Extrinsic motivation

The individual does not act for the pleasure and interest generated by the activity but to obtain something pleasurable or to avoid something unpleasant after the activity is completed, such as rewards, constraints, or punishments (Deci, 1975). For example, extrinsically motivated students tend to make the minimum effort to be rewarded (OCDE, 2000). Extrinsic motivation covers several forms, some of which are more self-determined than others. From the lowest level of self-determination to the highest, we cite extrinsic motivation by external regulation, introjected regulation, identified regulation, and integrated regulation (Sarrazin & Trouilloud, 2006).

The motivation by external regulation represents the least autonomous type of extrinsic motivation (Ryan & Deci, 2000). In this case, students act under material and/or social constraints (Berger & Rinaldi Davinroy, 2015).

The motivation by introjected regulation corresponds to the individual's commitment to an activity under pressure to avoid guilt, shame, and anxiety or to reinforce the ego and self-esteem (Ryan & Deci, 2000). With this type of motivation, students have internalized certain constraints that were previously external. When a student comes to class saying, "I have to prove to them that I am not bad ", this manifests introjected regulation (Sarrazin & Trouilloud, 2006).

The motivation by Identified regulation characterizes the individual who performs an activity and engages in it voluntarily because they have consciously recognized that the activity is important to them (Chédru, 2019). When a student comes to class saying, "what I am doing now will be very useful for later on", this manifest identified regulation (Sarrazin & Trouilloud, 2006).

Intrinsic motivation

Intrinsic motivation is found within the individual. According to this concept, the actions in which the individual engages respond to their own needs, interests, or even tastes and satisfy a particular tendency or orientation (Tardif, 1992). An individual is intrinsically motivated when they perform an activity voluntarily and out of interest in the activity. There are three types of intrinsic motivation: intrinsic motivation to know, intrinsic motivation toward accomplishment, and intrinsic motivation to experience stimulation (Vallerand et al., 1989).

Objectives

This article includes two studies:

1. The first study aims to
   - develop an Arabic version of PSLMS among Moroccan middle school students,
   - examine its factor structure, and
   - verify the distribution indices, internal consistency, and construct validity of the scale by testing the hypothesis concerning the self-determination continuum (Deci & Ryan, 1985), which postulates that correlations between motivation subscales adopt a simplex-type structure. This structure emerges when adjacent motivational concepts on the self-determination continuum show the most positive correlations, while correlations with more distant motivational concepts become progressively negative.
2. The purpose of the second study is to
   - confirm the factor structure of PSLMS with a larger target population and
   - verify the internal consistency of the subscales.

STUDY 1

Method

Development of scale

Our scale was inspired by the academic self-regulation questionnaire of Ryan and Connell (1989), which measures students' motivation to perform different school activities, such as working in class or doing homework. This scale was adapted to French by the researcher Leroy (2009) and consisted of 36 items. We chose 20 items divided into five dimensions of the scale in French: intrinsic motivation, three forms of extrinsic motivation (identified regulation, introjected regulation, and external regulation), and amotivation. In addition, we adapted the selected items in Arabic to the context of learning physical science in middle school.

The development of the Arabic version of PSLMS was carried out in two stages, as follows.

In the first stage, we modified the items of the original scale in its French version (Leroy, 2009), changing some terms.

In the second step, we translated the adapted items from the French version of the scale into Arabic and verified the authenticity of the translation by the method of translation/back translation; the French items were translated into Arabic by two bilingual people, then the Arabic scale was translated into French by two other bilingual people. The translations were compared to obtain a common translation.

20 selected items from PSLMS were used to measure five types of motivation divided, as follows:

1. six items for intrinsic motivation,
2. 11 items divided into three categories of extrinsic motivation: four items for extrinsic motivation by external regulation, four items for motivation by introjected regulation, and three items for motivation by identified regulation, and
3. three items for amotivation.

PSLMS used in this research is in the form of a Likert scale with five response levels: "strongly disagree"; "disagree"; "neither disagree nor agree"; "agree", and "strongly agree".

Participants

This study's sample comprises 144 students, divided between the third year (n=87) and the second year of middle school (n=57), from seven classes belonging to three establishments in the province of Sidi Slimane in Morocco. The sample was composed of 47.2% girls and 52.8% boys. The average age of the students was 15.32 years (standard deviation [SD]=1.034, min=13, max=19).

Procedure

Data was collected in March 2022 in the students' class. Participants were assured that no response was judged right or wrong and that all questionnaires would be treated confidentially. In addition, Before the questionnaire was given to the students, specific guidance was given to ensure that everyone had no problems with how to code. The participants finally completed the questionnaire in the form of a five-point Likert scale in the classroom, and the duration was 30 minutes.

Statistical analysis

In this study, we used SPSS V .21 software to check the normality of distribution, to perform principal component factor analysis, measure internal consistency, and determine correlations between the subscales of PSLMS.

Table 1. Means, standard deviation, & normality distribution indices for subscales & their items

Subscales & their items	Means	Standard deviation	Skewness	Kurtosis
IM	4.0567	.65585	-1.601	4.499
Q_3	3.9653	.93430	-1.026	1.068
Q_5	4.2569	.81718	-1.365	2.734
Q_8	4.1597	1.00114	-1.345	1.688
Q_{17}	3.9097	.97459	-1.150	1.335
Q_{18}	3.8681	.93305	-.885	.751
Q20	4.1806	.84995	-1.534	3.358
EMID	4.0417	.68492	-1.166	2.661
Q_2	4.1944	.80451	-1.186	1.958
Q_{16}	4.0139	.87695	-.658	.109
Q_{19}	3.9167	.97880	-.693	-.063
EMINJ	3.5313	.90351	-.376	-.624
Q_4	3.3264	1.26729	-.261	-1.157
Q_7	3.7708	1.08208	-.673	-.448
Q_{12}	3.3264	1.16972	-.105	-1.167
Q_{13}	3.7014	1.12243	-.621	-.493
EMEX	3.0191	.90939	-.203	-.644
Q_1	3.2500	1.20894	-.349	-.899
Q_6	3.4167	1.16775	-.544	-.616
Q_{11}	2.6667	1.24035	.102	-1.240
Q_{14}	2.7431	1.21613	.104	-1.118
AM	1.9375	.78146	.807	.351
Q_9	1.9028	.91849	.909	.356
Q_{10}	1.7639	.98226	1.389	1.532
Q_{15}	2.1458	1.07722	.828	.070

Note. IM: Intrinsic motivation; EMID: Extrinsic motivation by regulation identified; EMINJ: Extrinsic motivation by introjected regulation; EMEX: Extrinsic motivation by external regulation; AM: Amotivation; & Q: Item code

Results & Discussion

Normality of distribution

A descriptive analysis was carried out to assess the normality of the distribution for each of 20 items and subscales by calculating the degree of kurtosis and skewness of the data, the means, and SDs (see **Table 1**). The mean results indicate that there is no floor effect (value of one) and no ceiling effect (value of seven). According to Bentler (1985), Bentler and Newcomb (1986), and Kline (1998), the values of the kurtosis and skewness indices should be between +2 and -2. Although the kurtosis indices for intrinsic motivation items Q5 and Q20 are greater than two, indicating that the distributions contain too much data of the same frequency, the skewness index should not exceed three in absolute value, and the kurtosis index is sometimes accepted up to eight in absolute value (Roussel et al., 2002). Based on these recommendations, we decided to retain these items for the rest of our research, as they showed the best distribution indices in their respective categories. Overall, the results show acceptable values, indicating adequate normality of the data distributions.

Table 2. Results of exploratory principal component analysis with varimax rotation (n=144)

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Q_8	.770				
Q_{18}	.692				
Q_3	.671				
Q_{17}	.612				-.302
Q_{20}	.570			.480	
Q_5	.532			.335	
Q_7		.814			
Q_4		.770			
Q_{13}	.353	.752			
Q_{12}		.706			
Q_1			.765		
Q_{14}			.733		
Q_{11}			.732		
Q_6			.691		
Q_2				.808	
Q_{19}				.613	
Q_{16}	.417			.602	
Q_9					.770
Q_{15}					.705
Q_{10}	-.427				.678
Eigenvalue	4.847	3.019	1.588	1.364	1.073
VE	24.235	15.097	7.941	6.822	5.364

Note. Q: Item code; VE: Variance explained; EM: Extrinsic motivation; Factor 1: Intrinsic motivation; Factor 2: EM by introjected regulation; Factor 3: EM by external regulation; Factor 4: EM by identified regulation; & Factor 5: Amotivation

Exploratory factor analysis

The Kaiser-Meyer-Olkin (KMO) index measures the adequacy of the sampling. This index ranges from 0 to 1 and provides additional information to examine the correlation matrix. KMO index increases with sample size, number of variables, inter-item correlations, and number of factors. The index should be equal to or greater than 0.6 (Cohen et al., 2011). In this study, KMO coefficient is entirely satisfactory (KMO=0.796), as well as Bartlett's test of sphericity is statistically significant (χ^2=896.565, p<0.001). These results allow us to reject the null hypothesis of the equality of a correlation matrix with an identity matrix.

Principal component analysis (PCA) as a factor extraction procedure with varimax rotation was performed on 20 items of the Arabic version of PSLMS. We retained the factors with an *eigenvalue* greater than ONone (Kaiser, 1960). In addition, items with saturations below 0.3 are automatically deleted.

The results presented in **Table 2** reveal that the scale items were distributed over five factors, which is the same number as the theoretical model factors. These five factors explain 59.6% of the total variance. Gorsuch (1983) states that this percentage is above the minimum threshold (40.0%) in this type of analysis. Most of the items saturate on the same expected factor, except for some items that saturate on the expected factor and another different factor. We can see that items Q_8, Q_{18}, Q_3, Q_{17}, Q_{20}, and Q_5 have strong saturations on the first factor, representing the intrinsic motivation dimension. Both items Q_{20} and Q_5 also saturate with lower coefficients on the factor associated with the identified regulation motivation dimension. However, the two concepts of intrinsic and identified regulation motivation are theoretically adjacent on a continuum of self-determination, so the overlap of these two factors can be considered a minor difference. The second factor consists of items Q_4, Q_7, Q_{13}, and Q_{12}; it represents a dimension of extrinsic motivation by introjected regulation. The third factor comprises items Q_1, Q_{14}, Q_{11}, and Q_6; it defines a dimension of motivation by external regulation. Items Q_3, Q_{16}, and Q_{19} are strongly saturated on the fourth factor, representing a dimension of motivation by identified regulation. The fifth factor consists of items Q_9, Q_{10}, and Q_{15} and represents a dimension of amotivation. According to the criteria of Hair et al (2010) cited by Hidayat et al (2021), a factor saturation greater than 0.5 for each item is significant for validating the relevance of the questionnaire. In this analysis, all items have higher saturations (>0.5) on the expected same factor; so, we have retained them.

Internal consistency of subscales (study 1)

The internal consistency values of the five factors calculated from Cronbach's alpha (Cronbach, 1951) are intrinsic motivation (α=0.806), EM by identified regulation (α=0.656), EM by external regulation (α=0.745), EM by introjected regulation (α=0.782), and amotivation (α=0.69). According to Nunnally and Bernstein (1994), the internal consistency of the subscales must be greater than 0.70 to be acceptable. So, we can see that the subscales concerning motivation by identified regulation and amotivation do not reach this criterion, unlike the other three subscales. The internal consistency of these subscales, each composed of just three items, can be assessed as acceptable, based on the research of Kline (1993). In addition, according to Loewenthal's (1996) criteria, a Cronbach's alpha equal to or greater than 0.60 is considered acceptable for a dimension consisting of fewer than 10 items. Overall, all the subscales have acceptable internal consistency.

Construct validity: Correlations between the subscales of PSLMS.

Table 3 shows a matrix of Pearson correlations between the subscales of PSLMS. The results support the existence of the self-determination continuum proposed by Deci and Ryan (1985). We observed that the highest positive correlations are found between adjacent subscales and the highest negative correlations between the farthest subscales on this continuum. For example, intrinsic motivation is strongly positively correlated with EM by identified regulation (r=0.565, p<0.01), and EM by identified regulation is positively correlated with EM by introjected regulation (r=0.241, p<0.01). Thus, EM

Table 3. Correlations between different subscales of PSLMS

Subscales	1	2	3	4
1. IM	-			
2. EMID	.565**	-		
3. EMINJ	.215**	.241**	-	
4. EMXT	-.159	-.071	.239**	-
5. AM	-.474**	-.274**	-.062	.237**

Note. IM: Intrinsic motivation; EMID: Extrinsic motivation by regulation identified; EMINJ: Extrinsic motivation by introjected regulation; EMXT: Extrinsic motivation by external regulation; AM: Amotivation; *p<0.05; & ** p<0.01

by introjected regulation is strongly positively correlated with EM by external regulation (r=0.239, p<0.01). However, intrinsic motivation is strongly negatively correlated with amotivation (r=-0.474, p<0.01), and EM by identified regulation is negatively correlated with amotivation (r=-0.274, p<0.01). Several correlations are not significant; for example, EM by external regulation with the intrinsic motivation or with EM by regulation identified, then EM by introjected regulation with amotivation. The significant correlations respect the self-determination continuum relatively well (Deci & Ryan, 1985, 2000; Ryan & Connell, 1989) and therefore support the existence of a correlational profile known as simplex (Guttman, 1954).

STUDY 2

Method

Participants

The sample for this study comprises 404 students, divided between the third year (n=215) and the second year of middle school (n=189), from 16 classes belonging to six establishments in the same province as study 1. The sample was composed of 53.2% girls and 46.8% boys. The average age of the students was 14.92 years (SD=1.13, min=13, max=18).

Procedure

We followed the same procedure as in study 1.

Measuring instrument

As described in study 1 of this article, PSLMS was used to confirm its factor structure. The internal consistency of the scale in this study calculated from Cronbach's alpha is satisfactory (α=0.759).

Statistical analysis

In this study, SPSS V.21 software was used to measure the internal consistency of PSLMS subscales. CFA was performed to confirm the factor structure of the Arabic version of PSLMS using AMOS V.24 software. In addition, several goodness of fit indices were used to check the fit of the tested model to the data: Chi-square fit (χ^2) of Bollen (1989), Chi-square degree of freedom ratio (χ^2/dl; Marsh et al., 1996), the root mean square error of approximation (RMSEA) of Steiger (1990) and standardized root mean square residual (SRMR) of Bentler (1995). In addition, goodness of fit index (GFI), adjusted goodness of fit index (AGFI) of Jöreskog and Sörbom (1984), non-normed fit index (TLI) of Tucker and Lewis (1973), and comparative fit index (CFI) proposed by Bentler (1990).

Chi-square test assesses how well the formulated model reproduces the sample data. A non-significant Chi-square value indicates that the observed data fit the model well. The probability that the Chi-square value is significant increases with increasing sample size. The Chi-square/degree of freedom ratio partially corrects this problem (Hayduk, 1987). Thus, a value of the Chi-square/degree of freedom ratio smaller than five usually means that the data fit the proposed theoretical model well (Jöreskog & Sörbom, 1993). In addition, GFI and AGFI indices and CFI and TLI indices usually range from zero to one. In general, if the values of these indices exceed 0.90, it indicates a good fit for the model (Bentler & Bonett, 1980; Schumacker & Lomax, 1996). Concerning RMSEA index, some authors, such as Browne and Cudeck (1993), indicate that a value below 0.05 means a very good fitness level but that a value between 0.05 and 0.08 remains acceptable. Furthermore, the model with an SRMR value below 0.08 is generally considered adequate (Hu & Bentler, 1999).

Results & Discussion

Confirmatory factor analysis

To examine the internal structure of PSLMS, we conducted a CFA on the data collected from our sample to test our five-factor model, which consists of 20 selected items (see **Figure 1**). The statistical method of maximum likelihood estimation was performed to verify the level of fit of the model. In addition, we also used an analysis using the Lagrange multiplier test (Chou & Bentler, 1990), to improve the fit of the tested model by discovering possible covariances between the error terms of the latent variable indicators.

The first results indicate that the value of the Chi-square is significant (χ^2=549.535, p<0.001), RMSEA (0.078), and SRMR (0.0685) indices below 0.08, are therefore acceptable. The χ^2/dl ratio (3.435) was also satisfactory. However, the indices of GFI (0.881), AGFI (0.843), CFI (0.856), and the value of TLI (0.829) did not reach the threshold of 0.9, thus not constituting satisfactory values for a good fit of the model. These results confirm that modifications must be made to improve the model's fit. The five added constraints (see **Figure 1**) allow us to free the covariances between the errors of the indicators of the same factor. For example, we added the covariances between the errors of the indicators (item Q3-item Q17) of the same factor related

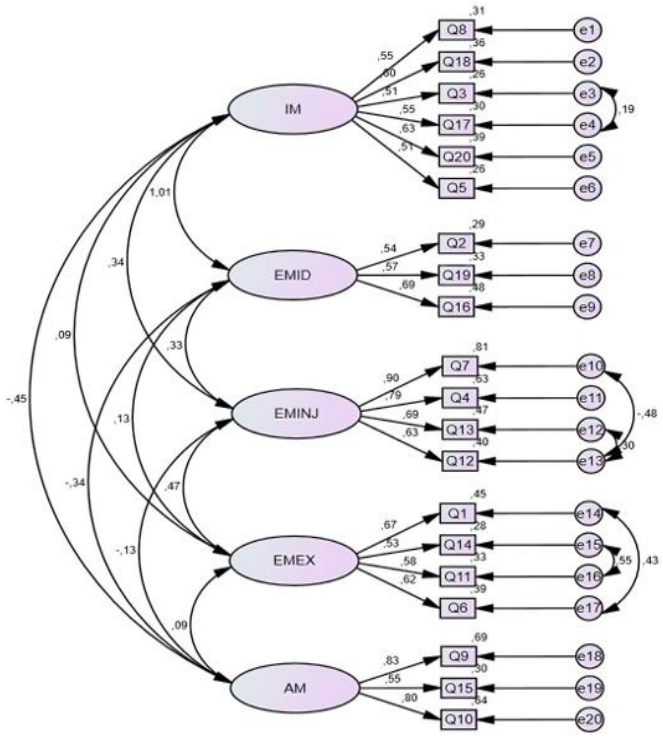

Figure 1. Standardized solution for CFA of PSLMS (IM: Intrinsic motivation; EMID: Extrinsic motivation by regulation identified; EMINJ: Extrinsic motivation by introjected regulation; EMEX: Extrinsic motivation by external regulation; AM: Amotivation) (Source: Authors' own elaboration)

to intrinsic motivation, as well as the covariances between the errors of the indicators (item Q7-item Q12 and item Q12-item Q13) of the same factor related to EM by introjected regulation and the covariances between the errors of the indicators (item Q1-item Q6 and item Q11-item Q14) of the same factor related to EM by external regulation. Insertion of the residual correlations allows us to obtain a better fit of data to model.

The results of the fit indices of the tested model after the added modifications indicate a significant Chi-square value (χ^2=295.36, p<0.001) and χ^2/dl ratio (1.906), which likely demonstrates that the data fit the theoretical model well. In addition, the values of GFI (0.932), AGFI (0.907), TLI (0.936), and CFI (0.948) are satisfactory. In addition, the values of RMSEA (0.047) and SRMR (0.0568) are also satisfactory. Thus, values of the indices obtained revealed a satisfactory fit and thus supported the five-factor structure of the Arabic version of PSLMS.

Internal consistency of subscales (study 2)

The internal consistency of each of the subscales of PSLMS was examined by calculating Cronbach's alpha coefficient. The values obtained ranged from 0.622 to 0.83. According to Nunnally and Bernstein (1994), many of the subscales have a good internal consistency higher than 0.7: intrinsic motivation (a=0.738), EM by introjected regulation (a=0.835), EM by external regulation (a=0.777) and amotivation (a=0.76).

The internal consistency of the EM by identified regulation subscale appears to be somewhat low by (a=0.622) and thus did not meet the expected threshold. This may be explained by the fact that this subscale consists of only three items, as Cronbach's alpha increases with the number of items included in a scale. Based on the work of Kline (1993), the internal consistency of this subscale can be considered acceptable.

OVERALL DISCUSSION

The purpose of the two studies conducted in this article was to validate an Arabic version of PSLMS. More specifically, developing an Arabic version of PSLMS and its construct validity describes the objective of the first study. Objective of the second study, on the other hand, was on confirming the factorial structure of PSLMS.

The results obtained in these studies confirm that PSLMS has satisfactory psychometric properties. In terms of internal consistency fidelity, the results of both studies indicate that PSLMS has satisfactory levels of internal consistency. Regarding the factorial validity of PSLMS, PCA, and CFA support the five-factor structure. In addition, the results of both studies show that the correlations between the subscales of PSLMS support the existence of the self-determination continuum postulated by self-determination theory (Deci & Ryan, 1985, 2000, 2002; Ryan & Connell, 1989). Indeed, a pattern of correlations of the so-called "simplex" type (Guttman, 1954) was obtained, where the highest positive correlations were observed between adjacent subscales, and the highest negative correlations were observed between the most distant forms of motivation on the continuum. Different scales measuring forms of motivation have used this system of correlations to demonstrate the presence of this continuum in other domains: education (Vallerand et al., 1992, 1993), work (Blais et al., 1993), sport (Pelletier et al., 1995), and family (Senécal & Vallerand, 1999).

However, it is essential to emphasize the limitations inherent in this research. Firstly, the temporal stability of the instrument was not assessed, which represents an initial limitation. Although construct validity was verified by correlations between the instrument's subscales, it is essential to note that construct validity by correlations between the instrument's subscales and other variables was not examined. In addition, it is important to note that the validity of the scale was established only with a sample of students in their second and third years of middle school, thus excluding the participation of first-year students in this research. Nevertheless, the students recruited came from a single province in Morocco (Sidi Slimane). It would be interesting to compare the results of this research with those of other provinces and regions, as well as with different subjects and grade levels, using larger samples.

CONCLUSIONS

The encouraging results of this research make PSLMS a tool that can be very useful in research, both in theory and practice. At the theoretical level, it is possible to test hypotheses regarding the antecedents, whether individual or contextual (e.g., teaching styles, perception of competence, and supportive climate) and consequences (e.g., academic achievement and perseverance) of various forms of student motivation in the context of physical science learning. Therefore, this tool will enable teachers and educationalists to understand the role of motivation in physical science learning. In short, PSLMS represents an innovative tool that could pave the way for new research in motivation.

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