A Cross-cultural Validation of Adapted Questionnaire for Assessing Motivation to Learn Science

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The aim of the present study was to examine the psychometric properties of a questionnaire adapted from Students’ Motivation Towards Science Learning questionnaire developed by Tuan and colleagues, to assess motivation to learn science among Namibian Grade 12 students (N = 755). The overall reliability of the scores on the 19-item questionnaire was 0.79. The reliability of the individual factors ranged from 0.66 to 0.77. The sample was split into two for exploratory and confirmatory factor analyses. Exploratory factor analysis (N = 403) using principal components extraction with varimax rotation revealed an interpretable factor structure and the factor solution accounted for 56.1% of the total variance. The measurement model was validated by means of confirmatory factor analysis (N = 352) and the results showed that the model had adequate statistical fit for the data, with the following fit indices: $\chi^2$/d.f. = 1.54, RMSEA = 0.039, SRMR = 0.047, TLI = 0.94 and CFI = 0.95. Construct validity was confirmed through the assessment of convergent and discriminant validity and both were found tenable. These findings indicate that the adapted questionnaire has adequate construct validity and reliability. Moreover, the findings suggest that the adapted questionnaire is suitable for assessing Namibian Grade 12 science students’ motivation to learn science.

Keywords: Motivation; learning science; cross-cultural validation; factor analysis

Introduction

Science education reforms in recent years have been advancing the development of students’ scientific literacy (National Academy of Sciences, 2010; National Research Council, 2007). The importance of having scientifically literate citizens who can make sense of the scientific issues that confront them cannot be over emphasised (Glynn, Taasoobshirazi, & Brickman, 2009). However, in the current educational climate in which such a high premium is put on students’ performance on standardized assessments, teachers have little time to allow their students to explore science concepts in interesting ways, thereby contributing to students’ perception of science as dull (Chen, Metcalf, & Tutwiler, 2014). Consequently, it becomes difficult to keep students motivated, especially during the middle school and high school years, when there is a noticeable general decline in motivation (Chen et al., 2014).

Against this background, the role of students’ motivation to learn has increasingly been receiving attention (Chen, 2012; Wang & Liou, 2017). Student motivation is a pivotal factor that influences their classroom engagement, learning performance and reason for doing a science task, which involves the students’ goals, interests and beliefs about the importance of the task (Ho & Liang, 2015). Research shows (for instance, see Pintrich & Schunk, 2002) that Students who are intrinsically motivated are found to be mastery goal-oriented and those who are extrinsically motivated are performance goal-oriented. In contrast, students who are surface motivated in learning tend to be motivated by external incentives such as higher grades or awards from teachers, and are performance goal-oriented (Pintrich & Schunk, 2002). Extensive evidence supports the conclusion that intrinsic and deep
motivation usually results in the adoption of deep learning strategies and better academic performance (Ho & Liang, 2015).

This study is part of a bigger study that attempts to assess Namibian Grade 12 students’ motivation to learn science and their scientific epistemic beliefs, and to relate these two aspects to their academic performance in science at the exit point of basic education in the Namibian education system (the senior secondary phase), in light of the assessment of the development of 21st century skills. However, this paper reports only on the adaptation and validation of a questionnaire for assessing Grade 12 students’ motivation to learn science.

A search for studies including online publications in repositories of local institutions in Namibia as well as on several international databases did not yield any reports of similar studies done in Namibia. Most of what is known about students’ motivation to learn science comes from other countries, particularly the developed world. Owing to the considerable differences in the educational and cultural context, the results from studies in developed world may or may not be transferable to Namibia. Thus, the present study seeks to instigate research on motivation to learn science among Namibian students.

The aim of the present study was therefore to validate an adapted form of the Students’ Motivation Towards Science Learning (SMTSL) questionnaire that was put forward by Tuan, Chin, and Shieh (2005), using a sample of Namibian Grade 12 students. This questionnaire was chosen for adaptation because of its high reliability with the original Taiwanese sample. Secondly, the original SMTSL questionnaire was administered to junior high school students in English, a second language to the Taiwanese respondents. English is the official language in Namibia but not the home language for the Namibian respondents. All items in the adapted questionnaire were also presented in English.

The original instrument consisted of 35 items from six factors. Its reliability (Cronbach’s α) was 0.89 while subscale reliability ranged from 0.70 to 0.89. Among the six factors, five were chosen for this study: (1) self-efficacy; (2) science learning value; (3) active learning strategies; (4) achievement goal; and (5) learning environment stimulation.

Self-efficacy is the confidence that students possess that they can achieve in science (Chumbley, Haynes, & Stofer, 2015). It relates to the individual’s ability to perform a specific task (Tuan et al., 2005). Higher self-efficacy means that the individual believes that he/she is capable of accomplishing learning tasks, whether such tasks are easy or difficult.

Science learning value refers to whether or not students can see the value of the science they engage in (Tuan et al., 2005). Problem-solving, scientific inquiry and relevance of science in students’ daily lives are some of the indicators of science value (American Association for the Advancement of Science, 1993).

Active learning strategies refers to the student taking an active role in using a variety of strategies to construct new knowledge based on previous understanding (Tuan et al., 2005). Achievement goal relates to the satisfaction experienced when competence and achievement increase during science learning (Elliot & Murayama, 2008). Learning environment stimulation is a form of extrinsic motivation related to the interaction that students have with their surroundings, which influences their motivation to learn, such as the curriculum, teaching strategies and peer interactions (Tuan et al., 2005).

The sixth factor, performance goal, refers to the student being motivated to learn just to compete with other students (good grades) and obtain attention from the teacher. This factor was not included in the present study because all items were viewed by the author as best assessed if they were reverse-coded and this was not preferred for this study. Reverse-coded items are intended to address response bias. Response bias refers to respondents answering patterns on questionnaires that do not reflect their actual state or opinion (van Sonderen, Sanderman, & Coyne, 2013). Although reverse-coding items can be used in instruments and can be reverse scored, it is often discouraged because it leads to confusion among respondents, especially second language speakers, who if they are not very careful may miss the reversing or the negative form and may incorrectly respond to the items (Weijters, Baunegartner, & Schillewaert, 2013).
Theoretical Framework

Motivation has roots in the social cognitive theory of human learning (Bandura, 2009; Pintrich, 2003). This theory postulates that there are tripartite reciprocal interactions between personal characteristics, behaviour and environmental context (Bandura, 2009). In this theory, students’ learning is construed as most effective when it is self-regulated and takes place when students understand, monitor and control their motivation and behaviours, which results in desirable academic achievement (Bandura, 2009; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011).

Moreover, motivation is viewed as an internal process that arouses, directs and sustains goal-oriented activity (Glynn et al., 2009). In particular, motivation to learn refers to individuals’ inherent qualities of mind and character that enable them to view academic activities as relevant and worthwhile (Glynn et al., 2009). In the context of motivation to learn science, the internal process arouses, directs and sustains science-learning behaviour (Glynn et al., 2011). Motivated students achieve academically by engaging in behaviour that enables them to actively participate in a learning task. Consequently, assessment of motivation to learn science is concerned with establishing why students endeavour to learn science, how intensively they make such endeavours and the beliefs, feelings and emotions that characterise them in this process (Glynn et al., 2009). Students’ self-efficacy, science learning value, learning strategies, learning goal and the learning environment stimulation are some of the important motivational factors attributable to science learning motivation (Tuan et al., 2005). Such factors were adapted for this study as the basis for assessing Namibian Grade 12 students’ motivation to learn science. The original instrument was developed for a particular culture and in the present study it has been adapted for a different culture. This necessitates a cross-cultural validation.

Cross-cultural validation entails ascertaining whether instruments that were originally developed in a particular culture are meaningfully applicable and thus equivalent for use in another culture (Huang & Wong, 2014). It has often been applied in psychological studies in which self-reporting measures are adapted for use in languages other than the original one. However, in the present study, both the original and the adapted version were in English. Cultural difference exists only in terms of geographical location: the original questionnaire was developed in Taiwan (Asia) and the adapted version was used in Namibia (Africa).

Huang and Wong (2014) asserted that it might be challenging to adapt an instrument in a culturally relevant and comprehensible form while maintaining the meaning of the original items. In the context of the present study, the adaptation entailed rephrasing and omitting statements that were not deemed relevant to the Namibian context or did not use local terminology. At the discretion of the author, an attempt was made to shorten the questionnaire in order to mitigate respondents’ fatigue. Factors such as self-efficacy had seven items in the original version but five of them were in the negative (reverse) format (i.e. I am not confident about understanding difficult science concepts; No matter how much effort I put in, I can’t learn science, etc.), which was not desirable in this study as explained above. Such items were rewritten in the positive format and there were finally four items for this factor (see Table 3). The factors active learning strategies and learning environment stimulation had eight and six items respectively. In the quest to come up with a shorter questionnaire, such items were combined and/or rephrased. For the reminder of the factors, items were rephrased by mainly replacing the word ‘course’ with ‘lesson’. The original version of the SMTSL questionnaire consisting of 35 items can be found in the Tuan et al. (2005) article published in the International Journal of Science Education.

Owing to the adaptation of the questionnaire and the use of a sample different from the original one, it is recommended to examine the psychometric properties of the adapted instrument in order to assess its measurement precision and validity (Schraw, Bendixen, & Dunkle, 2002). Modern statistical techniques such as principal component and confirmatory factor analyses were used.

Methods

Participants and Procedure
After obtaining ethical approval from the university’s institutional review board as well as permission from the gate keepers at the Ministry of Education in Namibia, consent forms were signed by
participating students in conjunction with their parents or guardians. A total of 755 Grade 12 students (male 53% and female 47%) from four senior secondary schools in two regions (Omusati and Ohangwena) of Namibia participated in the study. The mean age of students was 18.3 and the standard deviation was 1.32. Sampling was inherently convenient because the aim of the study was not to generalize findings but rather to obtain a sufficient sample suitable for advanced statistical analysis to examine the psychometric properties of the questionnaire. The sample was randomly split into two; 403 students’ scores were used for exploratory factor analysis (EFA) by means of principal components and 352 students’ scores were used for confirmatory factor analysis (CFA). This was done because it is advisable to use different samples for EFA and CFA (Cabrera-Nguyen, 2010; Henson & Roberts, 2006; Worthington & Whittaker, 2006).

All participating students were at senior secondary level (Grade 12). Students responded to the items using the paper-and-pencil method. The students in the two regions come from different socio-economic backgrounds. However, their general characteristics are similar because the two regions are predominantly rural areas. On average, students spent approximately 10 minutes completing the questionnaire.

**Instruments**
The 19-item questionnaire was adapted from the SMTSL questionnaire (Tuan et al., 2005). Students were asked to indicate the extent to which they were willing to learn science. Using recommendations from DeVellis (2003), the items were positively worded and unambiguously short, declarative statements without jargon. Each item was a five-point Likert scale of temporal frequency (Glynn et al., 2009), wherein 1 = never, 2 = rarely, 3 = sometimes, 4 = usually and 5 = always. Each item had to be answered by means of circling the number corresponding to the option that best described their beliefs. All items were worded in a positive direction so that a high score on a particular factor indicates a high level of motivation. The adapted questionnaire was given to two university lecturers of English and Linguistics who proof-read it and made suggestions for the final questionnaire.

Students’ responses were captured manually and incomplete questionnaires were discarded, hence no missing data are found in the dataset.

**Data Analysis**
Ordinal data were analysed as if they were interval data. The reliability of the scales was assessed using Cronbach’s $\alpha$ coefficient (Summers & Abd-El-Khalick, 2017), using the Statistical Package for Social Sciences version 25. Construct validity was assessed considering two criteria: convergent and discriminant (Cristobal, Flavián, & Guinaliu, 2007).

The structure of the adapted questionnaire was assessed by exploratory factor analysis using principal components extraction with varimax rotation (Henson & Roberts, 2006). The goodness of fit of the measurement model (hypothesized five-factor model) was assessed by confirmatory factor analysis (Glynn et al., 2011; Teo, 2013) using AMOS version 25.

Some methodological limitations may have influenced the findings of this study. First, students were not interviewed to ascertain accuracy of interpretation of the questionnaire items. It was assumed that students interpreted the items as expected. Secondly, factor retention in EFA was based only on the criterion eigenvalue greater than 1, which is prone to underestimating the number of factors (Henson & Roberts, 2006). Thirdly, the indices of model fit obtained from CFA might be biased owing to departure from multivariate normality (Cabrera-Nguyen, 2010).

**Results and Discussions**

**Reliability**
Reliability is a measure of internal consistency of respondents’ responses across the items on a multiple-item measure. Essentially, all the items on such measures should reflect the same underlying construct and thus respondents’ scores on those items should be correlated with each other (Wieland, Durach, Kembro, & Treiblmaier, 2017). This measure is commonly estimated using
Cronbach’s α reliability coefficient. Streiner (2003) suggested that the α coefficients of 0.70 and higher are ideal for research tools.

The reliabilities of the scores from the five factors in the questionnaire for this study were assessed using Cronbach’s α coefficient. The overall reliability of the scores on the adapted questionnaire was 0.79. The reliability of scores from individual factors ranged from 0.66 to 0.77 (Table 1), suggesting that the questionnaire had reasonable overall reliability for the sample used, although some individual factors showed reliability values below the recommended thresholds (achievement goal = 0.67 and active learning strategies = 0.66). However, such a finding is not surprising because the reliability of the adapted questionnaire in the Namibian cultural context was quite similar to that in previous studies (Yilmaz & Cavas, 2007; Dermizaki, Stavroussi, Vavougios & Kotsis, 2013) that adapted the same questionnaire in different cultural settings of Turkey and Greece, respectively.

**Construct Validity**

**Convergent validity**

Convergent validity measures the level of correlation of multiple variables of the same construct that are in agreement (Ab Hamid, Sami & Sidek, 2017). To establish convergent validity, factor loadings of indicator variables, composite reliability (CR) and the average variance extracted (AVE), should be used (Ab Hamid et al., 2017). The recommended thresholds for these measures are that the AVE should be above 0.50 and the CR should be 0.70 and above. However, when the AVE values are less than 0.40 and the composite reliability is higher than 0.60, the convergent validity of the construct may still be adequate (Fornell & Larcker, 1981). Convergent validity was evaluated using AVE and CR values computed using Microsoft Excel (Gaskin, 2016) and factor loadings from confirmatory factor analysis computed in AMOS version 25. The AVE values for the five latent factors ranged from 0.32 to 0.47. The CR values ranged from 0.63 to 0.78 (Table 1).

Although the AVE values for all latent factors were below the preferred minimum cut-off point of 0.50, convergent validity may still be adequate because most factors had AVE values above 0.40 (minimal acceptance level) except for two factors (achievement goal = 0.32 and science learning value = 0.37) and all factors had CR values above 0.60 (Fornell & Larcker, 1981). Malhotra and Dash (2011) also argued that the AVE is often too strict and validity can be established through CR alone.

**Discriminant validity**

The extent to which latent factors differ from each other empirically defines discriminant validity (Hair, Hult, Ringle, & Sarstedt, 2016). This means that a latent factor should explain the variance of its own indicators better than the variance of other latent factors (Ab Hamid et al., 2017). Discriminant validity was assessed by comparing the square root of the AVE with the correlation of latent factors (Hair et al., 2016). The square root of the AVE should be greater than 0.50 (Fornell & Larcker, 1981) and greater than inter-latent factor correlations within the model (Hair, Black, Babin, & Anderson, 2010). The maximum shared variance (MSV) was also compared with the AVE values. The AVE values should be greater than the MSV values for each latent factor (Rebelo-Pinto, Pinto, Rebelo-Pinto, & Paiva, Table 1. Reliability analyses of the scales and the questionnaire (N = 755)

<table>
<thead>
<tr>
<th>Latent factors</th>
<th>No. of items</th>
<th>CR</th>
<th>AVE</th>
<th>Alpha (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement goal</td>
<td>4</td>
<td>0.65</td>
<td>0.32</td>
<td>0.67</td>
</tr>
<tr>
<td>Learning environment stimulation</td>
<td>4</td>
<td>0.78</td>
<td>0.47</td>
<td>0.77</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>4</td>
<td>0.73</td>
<td>0.42</td>
<td>0.70</td>
</tr>
<tr>
<td>Active learning strategies</td>
<td>3</td>
<td>0.72</td>
<td>0.40</td>
<td>0.66</td>
</tr>
<tr>
<td>Science learning value</td>
<td>4</td>
<td>0.63</td>
<td>0.37</td>
<td>0.73</td>
</tr>
<tr>
<td>Overall reliability (α)</td>
<td>19</td>
<td></td>
<td></td>
<td>0.79</td>
</tr>
</tbody>
</table>

CR, Composite reliability; AVE, average variance extracted.
Table 2 shows the correlation matrix, the AVE values, the square root of the AVE values and the MSV of each latent factor.

As is evident in Table 2, the square root of the AVE (in italics) was greater than 0.50 and greater than inter-latent factor correlations within the model. All latent factors support these requirements and the discriminant validity of all latent factors is confirmed.

Exploratory Factor Analysis

Exploratory factor analysis is meant for cases where the relationships between the observed and latent variables are uncertain (Glynn et al., 2011). It was necessary to apply exploratory factor analysis to assess students’ responses to the questionnaire because it was adapted from an existing questionnaire (STMSL) that was originally used with a different culture and items were rewritten to suit students’ comprehension in the Namibian context. The assessment of the correlation matrix for the 19 items was found to be appropriate for factor analysis by means of a Bartlett’s test of sphericity, $\chi^2 = 1598.62$, d.f. = 171, $p < 0.001$, and the Kaizer–Meyer–Olkin measure of sampling adequacy, KMO = 0.77. These tests of normality and sampling adequacy indicated that the correlation matrix was of acceptable quality (Glynn et al., 2011).

Exploratory factor analysis was conducted on the 19 items ($N = 403$) using principal components extraction with varimax rotation. Although direct oblimin rotation was also explored with similar results, varimax rotation produces a factor structure that is clearly interpretable (Henson & Roberts, 2006). The analysis yielded five factors with eigenvalues greater than 1 and the factor solution accounted for 56.1% of the total variance. Table 3 shows the factor loadings.

All items in Table 3 loaded above 0.5 (loading values in italic) on their respective factor; none of the cross-loadings exceeded 0.32 (Worthington & Whittaker, 2006). The eigenvalues and the percentage of variance explained by each factor were learning environment stimulation (4.0, 21.09%), self-efficacy (2.16, 11.34%), active learning strategies (1.71, 9.02%), achievement goal (1.59, 8.35%) and science learning value (1.19, 6.27%).

Confirmatory Factor Analysis

Using a separate sample of 352 students, confirmatory factor analysis was performed on the 19 items to validate the measurement model in which construct and discriminant validity were assessed. The assessment of the model fit was done using the standardisation method where all covariances were set to 1.0 (Teo, 2013). The goodness of fit of the measurement model (hypothesized five-factor model) was assessed by three absolute ($\chi^2$, RMSEA, & SRMR) and two incremental (TLI and CFI) fit indices, as specified below.

The chi-square ($\chi^2$) statistic assesses the extent to which the proposed model varies from the data (Glynn et al., 2011). Its $p$-values are acceptable when they are non-significant, indicating adequate model fit. However, this index is sample dependent, hence it is recommended that it should be divided by the degrees of freedom ($\chi^2$/d.f.; Garson, 2015) and the resultant values should be in a recommended range of 1.0–3.0 (Glynn et al., 2011). The root-mean-square error of approximation

<table>
<thead>
<tr>
<th>Latent factors</th>
<th>$M$</th>
<th>SD</th>
<th>AVE</th>
<th>MSV</th>
<th>AG</th>
<th>LES</th>
<th>SE</th>
<th>ALS</th>
<th>SLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement goal</td>
<td>17.8</td>
<td>2.0</td>
<td>0.32</td>
<td>0.28</td>
<td>0.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning environment stimulation</td>
<td>14.7</td>
<td>3.0</td>
<td>0.47</td>
<td>0.10</td>
<td>0.17</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>15.6</td>
<td>2.6</td>
<td>0.42</td>
<td>0.16</td>
<td>0.34</td>
<td>0.32</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active learning strategies</td>
<td>16.8</td>
<td>2.3</td>
<td>0.40</td>
<td>0.15</td>
<td>0.38</td>
<td>0.13</td>
<td>0.29</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Science learning value</td>
<td>12.7</td>
<td>1.7</td>
<td>0.37</td>
<td>0.28</td>
<td>0.53</td>
<td>0.31</td>
<td>0.40</td>
<td>0.25</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Note: The diagonal numbers in italics are the square root of the AVE values. $M$, mean; SD, standard deviation; MSV, maximum shared variance; AG, achievement goal; LES, learning environment stimulation; ALS, Active learning strategies; SLV, science learning value.
Table 3. Rotated factor matrix

<table>
<thead>
<tr>
<th>Factors and items</th>
<th>LES</th>
<th>SE</th>
<th>ALS</th>
<th>AG</th>
<th>SLV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning environment stimulation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am willing to participate in science lessons because the teacher pays attention to me</td>
<td>0.800</td>
<td>0.038</td>
<td>0.038</td>
<td>0.022</td>
<td>0.041</td>
</tr>
<tr>
<td>I am willing to participate in science lessons because learners are involved in discussions</td>
<td>0.785</td>
<td>0.015</td>
<td>0.048</td>
<td>0.012</td>
<td>0.092</td>
</tr>
<tr>
<td>I am willing to participate in science lessons because the content is exciting</td>
<td>0.721</td>
<td>0.217</td>
<td>0.007</td>
<td>0.073</td>
<td>0.117</td>
</tr>
<tr>
<td>I am willing to participate in science lessons because the teacher does not put a lot of pressure on me</td>
<td>0.713</td>
<td>0.077</td>
<td>0.074</td>
<td>0.020</td>
<td>0.065</td>
</tr>
<tr>
<td><strong>Self-efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am confident about understanding difficult science concepts</td>
<td>0.121</td>
<td>0.827</td>
<td>0.049</td>
<td>0.096</td>
<td>0.048</td>
</tr>
<tr>
<td>I am sure that I can understand science content even when it is difficult</td>
<td>0.050</td>
<td>0.790</td>
<td>0.109</td>
<td>0.021</td>
<td>0.082</td>
</tr>
<tr>
<td>I always try to understand science concepts</td>
<td>0.176</td>
<td>0.701</td>
<td>0.178</td>
<td>0.089</td>
<td>0.083</td>
</tr>
<tr>
<td>I try to understand by myself rather than ask for help with science tasks</td>
<td>0.010</td>
<td>0.563</td>
<td>−0.079</td>
<td>0.143</td>
<td>0.062</td>
</tr>
<tr>
<td><strong>Active learning strategies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I do not understand a science concept, I discuss with others to clarify my understanding</td>
<td>0.005</td>
<td>0.085</td>
<td>0.778</td>
<td>0.142</td>
<td>0.046</td>
</tr>
<tr>
<td>When I do not understand a science concept, I use other sources of information</td>
<td>0.087</td>
<td>0.048</td>
<td>0.739</td>
<td>0.042</td>
<td>−0.063</td>
</tr>
<tr>
<td>When I meet science concepts that I do not understand, I still try to learn them</td>
<td>−0.025</td>
<td>0.049</td>
<td>0.671</td>
<td>0.107</td>
<td>0.105</td>
</tr>
<tr>
<td>When I learn new science concepts, I connect them to my previous understanding</td>
<td>0.105</td>
<td>0.019</td>
<td>0.659</td>
<td>0.036</td>
<td>0.168</td>
</tr>
<tr>
<td><strong>Achievement goal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel good when my science teacher accepts my ideas during science lessons</td>
<td>0.051</td>
<td>0.050</td>
<td>0.015</td>
<td>0.764</td>
<td>0.176</td>
</tr>
<tr>
<td>I feel good when other learners accept my ideas during science lessons</td>
<td>0.189</td>
<td>0.022</td>
<td>0.075</td>
<td>0.704</td>
<td>−0.090</td>
</tr>
<tr>
<td>I feel good when I am able to solve a difficult science task</td>
<td>−0.013</td>
<td>0.149</td>
<td>0.115</td>
<td>0.632</td>
<td>0.233</td>
</tr>
<tr>
<td>I feel very good when I get good marks in science tests</td>
<td>−0.124</td>
<td>0.203</td>
<td>0.185</td>
<td>0.621</td>
<td>0.163</td>
</tr>
<tr>
<td><strong>Science learning value</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think learning science is important because it stimulates my thinking</td>
<td>0.085</td>
<td>0.151</td>
<td>0.051</td>
<td>0.084</td>
<td>0.769</td>
</tr>
<tr>
<td>I think it is important to learn science because it provides an opportunity to satisfy my own curiosity</td>
<td>0.094</td>
<td>0.041</td>
<td>0.105</td>
<td>0.160</td>
<td>0.762</td>
</tr>
<tr>
<td>I think it is important to participate in science activities during learning</td>
<td>0.109</td>
<td>0.060</td>
<td>0.077</td>
<td>0.122</td>
<td>0.678</td>
</tr>
</tbody>
</table>

Note: Factor loadings of items in *italics* all exceeded the 0.32 criterion on their targeted factor (N = 403).

(RMSEA) and the standardized root mean square residual (SRMR) are independent of the sample size but are sensitive to model misspecification, and adequate fit values should be 0.06 and 0.08 or less, respectively (Teo, 2013). The Tucker–Lewis index (TLI) and the comparative fit index (CFI) are incremental indices with a recommended cutoff value of 0.95, indicating goodness of fit; however, values above 0.90 are acceptable (Hooper, Coughlan, & Mullen, 2008). Maximum likelihood estimation was used to estimate the model’s parameters and fit indices.

The analysis of the 19-item five-factor model yielded fit indices of $\chi^2$/d.f. = 1.54, for the data, RMSEA = 0.039, SRMR = 0.047, TLI = 0.94 and CFI = 0.95, indicating that the measurement model fit the data well. The standardised factor loadings and correlations among the factors from AMOS version 25 are shown in Figure 1. Factor loadings are estimated correlations which indicate how well a given item measures its corresponding factor (Glynn et al., 2011).
In comparison with similar previous studies (Yılmaz & Cavas, 2007; Dermitzaki et al., 2013), the present study showed better model fit indices. The two previous studies adapted the SMTSL as a whole into Turkish and Greek, respectively, while in this study, the adaptation maintained the language (English) of the instrument and used only five out of the six factors in the original questionnaire.

Figure 1. Confirmatory factor analysis: standardised loadings and correlations (N=352). Note: latent factors—LES, learning environment stimulation; SE, self-efficacy; ALS, active learning strategies; AG, achievement goal; SLV, science learning value; and e, error terms.

In comparison with similar previous studies (Yılmaz & Cavas, 2007; Dermitzaki et al., 2013), the present study showed better model fit indices. The two previous studies adapted the SMTSL as a whole into Turkish and Greek, respectively, while in this study, the adaptation maintained the language (English) of the instrument and used only five out of the six factors in the original questionnaire.

Conclusion

This study examined the factorial validity of the five-factor model of the adapted SMTSL questionnaire on a sample of Grade 12 students in Namibia. These findings indicate that the adapted questionnaire may have adequate construct validity although convergent validity, being one of the criteria for determining construct validity, showed marginally acceptable properties in terms of latent factors having AVE values below the preferred minimum cut-off point of 0.50. In support, most of the factors had
CR values above 0.70 with only two factors not meeting this criterion. Nonetheless, those two factors had CR values above 0.60, which is a moderately acceptable level of reliability. It is argued that the AVE is often too strict and on the basis of CR alone the researcher may conclude that the convergent validity of the construct may still be adequate, even though more than 50% of the variance is due to error (Malhotra & Dash, 2011). Similarly, the reliability of responses in terms of both $\alpha$ coefficient and composite reliability estimates was reasonable although the estimates for some factors were below the preferred cut-off point of 0.70. The measurement model shows acceptable fit for the data with good fit statistics such as $\chi^2$/d.f., RMSEA, SRMR, TLI and CFI. In comparison with similar previous studies, the present study showed better model fit indices.

The findings suggest that the adapted instrument is suitable for assessing Namibian Grade 12 science students’ motivation to learn science, particularly in large-scale cross-sectional studies. The questionnaire may also be combined with other scales for data collection that include comparisons of motivation to learn science with other variables such as demographic, achievement in science and scientific epistemic beliefs. This study focused on the exit phase of the Namibian basic education phase. At the moment, there are no formal assessments for students’ motivation to learn generally within the Namibian education system. However, knowing what motivates students to learn can help inform the development and improvement of current education policies. Given the paucity of similar instruments in the Namibian cultural context, this adaptation and validation may serve as a gateway for future similar studies particularly focusing on other, lower, stages of schooling. Copyright for the original instrument is with the International Journal of Science Education. However, the authors were acknowledged accordingly in the present study and the adapted items for this study can be found in Table 3 under the subheading ‘Exploratory factor analysis’.

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