Electronic supplemental material #2

This electronic supplemental material provides information about the development and psychometric evaluation of the ad hoc measurement instrument used in the parent article entitled "The Effect of Guidance during Inquiry Instruction on School Science Achievement Motivations".

Development of the instrument

An ad hoc questionnaire was designed by adapting items from existing research (i.e., Ball, Huang, Cotten, Rikard, & Coleman, 2016; Kosovich, Hulleman, Barron, & Getty, 2015; Wigfield & Cambria, 2010). It is worth mentioning that the use of broad and general items is a common practice in the measurement of achievement motivations following the expectancy-value framework (see Table 1 for extant items). An initial list of positively worded items was developed by the author of this study. Next, items were translated into Spanish following cross-cultural adaptation guidelines, consisting of (i) forward translation from the source to the target language; (ii) back-translation the Spanish items into the source language; (iii) committee revision and agreement by two bilingual English translators and the author of this study (Beaton et al., 2000). Next, the six elementary school teachers participating in this study reviewed the items and selected the most appropriated for the developmental stage of the students surveyed. Finally, six students enrolled in sixth grade of elementary education were think-aloud interviewed to assess comprehensibility and interpretation of the items (Beatty & Willis, 2007).

Table 1. Example of items used in the literature to measure values and expectancies of success

	Task values	Expectancies of success
Ball et al., (2016)	1. Going to school is fun. 2. I work hard at school because I am interested in what I am learning. 3. I try hard at school because I am interested in my work	1. I can spell as well as most kids my age. 2. I usually do a good job on tests. 3. I can read as well as most kids my age. 4. I get good grades in school. 5. I am able to do my schoolwork well
Kosovich et al., (2015)	1. I think my [math or science] class is important. 2. I value my [math or science] class. 3. I think my [math or science] class is useful.	1. I know I can learn the material in my [math or science] class. 2. I believe that I can be successful in my [math or science] class 3. I am confident that I can understand the material in my [math or science] class
Eccles et al., (1993)	1. How much do you like doing math? 2. In general, I find working on math assignments (very boring, very interesting)	-
Pintrich et al., (1993)	1. I like what I am learning in this class 2. I think that what I am learning in this class is useful for me to know	-
Putwain et al., (2019)	1. I find maths lessons interesting. 2. I find doing maths interesting. 3. I am interested in learning maths. 4. Maths is not interesting.	1. I get good marks for my maths work 2. I am good at maths tests 3. I get good marks in maths lessons 4. I think that I will do well in my next maths test

Psychometric evaluation of the instrument

Several analyses were performed using SPSS v.25 and AMOS v.23 statistical software. To start with, the psychometric properties (i.e., construct validity and reliability) of the ad hoc measures were examined. Specifically, construct validity was examined in two phases. First, since expectancies of success and intrinsic values are expected to correlate, data were subjected to exploratory factor analysis (EFA) with principal axis factoring extraction method and Promax oblique rotation to establish the underlying latent factors (Gaskin & Happell, 2014).

The number of factors to retain was determined based on Kaiser's (1970) eigenvalue above 1 criteria, conceptual distinction between factors, Catell's (1966) scree plot, and Horn's (1965) parallel analysis. Only items with a minimum of factor loading of $\lambda = 0.32$ on solely one factor were retained (Kline, 2014; Tabachnick & Fidell, 2007). Next, results of EFA were subjected to confirmatory factor analysis (CFA) to establish the model fit according to the following goodness-of-fit indices (Brown, 2006; Browne & Cudeck, 1993): (i) comparative fit index (CFI) ≥ .95; (ii) root mean square error of approximation (RMSEA) ≤ .05 and (iii) standardized root mean square residual (RMR) ≤ .08. Finally, Cronbach α was calculated for each factor and pedagogical condition as means of internal consistency reliability (Taber, 2018).

Results

Table 2 provides results of Horn's (1965) parallel analysis, indicating the extraction of two factors.

Table 2. Parallel analysis results

Factors	EFA	Parallel analysis	Decision
1	**3.58**	**1.53**	**Retain**
2	**1.70**	**1.36**	**Retain**
3	.96	1.26	Reject
4	.88	1.16	Reject
5	.69	1.05	Reject

Note. EFA = exploratory factor analysis.

Figure 1 provides results of Kaiser's (1970) eigenvalue > 1, which suggest a significant drop in eigenvalues after the second factor.

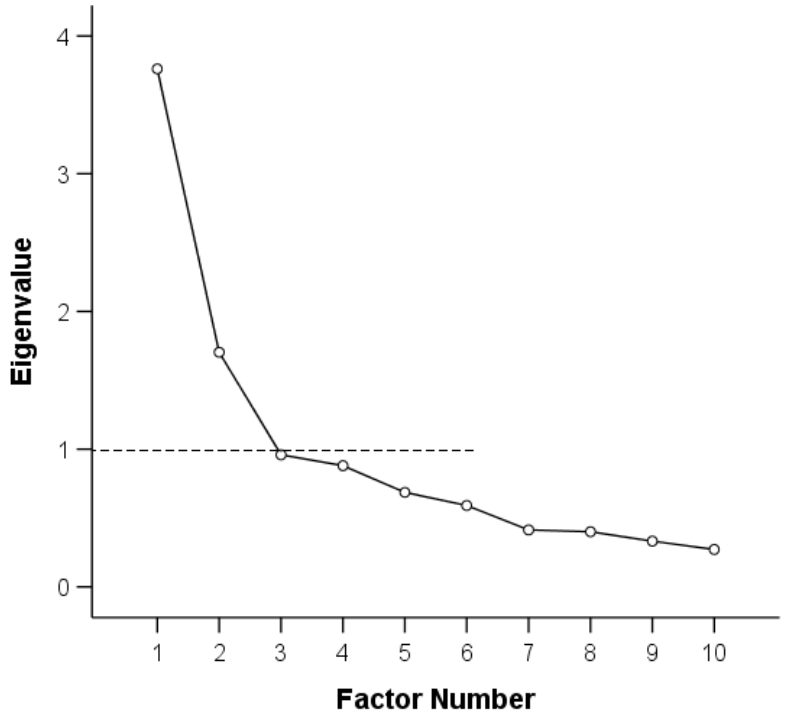

Figure 1. Catell's (1966) scree plot

As a result, it was decided to retain two factors. EFA and CFA revealed a parsimonious structure with all items loading on only one factor, and loadings above the minimum standard (Table 3). Likewise, the factor structured yielded a good model fit (χ^2= 26.22, df = 25, p = .40; CFI = .99, RMSEA = 0.02, RMR = 0.05).

Table 3. EFA and CFA factor loadings

Items	EFA		CFA	
	1	2	1	2
Intrinsic value				
I enjoy school science	.91		.87	
I am interested in the things I learn in school science.	.78		.80	
I have fun in school science	.71		.70	
I think science is cool	.62		.67	
Expectancy of success				
I do great in school science		.75		.79
I can do my science schoolwork well		.68		.62
School science is easy for me		.57		.58
I can get good grades in school science		.56		.45
I think I am very good at school science		.51		.55
Eigenvalues	3.58	1.70	-	-

Note. EFA (exploratory factor analysis); CFA (confirmatory factor analysis). Loadings below .32 were omitted for legibility purposes.

The Cronbach α was .78 (control), .71 (confirmatory) and .73 (structured) for the expectancy of success scale, and .85 (control), .84 (confirmatory) and .82 (structured) for the intrinsic value scale. Overall, this findings provides initial evidence of construct validity and internal consistency reliability for the instrument used.

References

Author (2020). *Research in Science Education*.

Ball, C., Huang, K. T., Cotten, S. R., Rikard, R. V., & Coleman, L. T. O. (2016). Invaluable values: an expectancy-value theory analysis of youths' academic motivations and intentions. *Information Communication and Society*, *19*(5), 618–638. https://doi.org/10.1080/1369118X.2016.1139616

Beaton, D. E., Bombardier, C., Guillemin, F., & Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine*, *25*(24), 3186–3191. https://doi.org/10.1097/00007632-200012150-00014

Beatty, P. C., & Willis, G. B. (2007). Research synthesis: The practice of cognitive interviewing. *Public Opinion Quarterly*, *71*(2), 287–311. https://doi.org/10.1093/poq/nfm006

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. Guilford Press.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing Structural Equation Models* (pp. 136–162). Sage.

Catell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research*, *1*, 245–276.

Eccles, J. S., Wigfield, A., Harold, R. B., & Blumenfeld, P. B. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development*, *64*, 830–847.

Gaskin, C. J., & Happell, B. (2014). On exploratory factor analysis: A review of recent evidence, an assessment of current practice, and recommendations for future use. *International Journal of Nursing Studies*, *51*, 511–521. https://doi.org/10.1016/j.ijnurstu.2013.10.005

Horn, J. L. (1965). A rationele and test for the number of factors in factor analysis. *Psychometrika*, *30*, 179–185.

Kaiser, H. (1970). A second generation Little Jiffy. *Psychometrika*, *35*, 401–415.

Kline, P. (2014). *An easy guide to factor analysis*. Routledge.

Kosovich, J. J., Hulleman, C. S., Barron, K. E., & Getty, S. (2015). A practical measure of student motivation: Establishing validity evidence for the expectancy-value-cost scale in middle school. *Journal of Early*

Adolescence, *35*(5–6), 790–816. https://doi.org/10.1177/0272431614556890

Pintrich, P. R., Smith, D. A., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the motivational strategies for learning questionnaire. *Educational and Psychological Measurement*, *53*, 801–813. https://doi.org/10.1177/0013164493053003024

Putwain, D. W., Nicholson, L. J., Pekrun, R., Becker, S., & Symes, W. (2019). Expectancy of success, attainment value, engagement, and Achievement: A moderated mediation analysis. *Learning and Instruction*, *60*(February 2018), 117–125. https://doi.org/10.1016/j.learninstruc.2018.11.005

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics (5th ed)*. Pearson Education.

Taber, K. S. (2018). The use of Cronbach's Alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review*, *30*(4), 1–35. https://doi.org/https://doi.org/10.1016/j.dr.2009.12.001