RELIABILITY AND VALIDITY OF A MALAY VERSION INSTRUMENT ON ATTITUDES TOWARDS SCIENCE

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There is abundance evidence to show that students' attitudes towards science are related to a number of variables that include student achievement. However, a valid and reliable Malay version instrument that measures such attitudes remains a scarcity. This paper reports on the establishment of validity and reliability for a Malay version instrument on attitudes towards science, which is a translation from the instrument developed by Germann (1988). Test-retest and Cronbach's alpha reliabilities are found to be at 0.93 and 0.90 respectively. Through factor analysis, the instrument was refined to a parsimonious version with its unidimensionality justified.

INTRODUCTION

The development of positive attitudes towards science has been one of the legitimate goals of science education globally. Some studies have shown that attitudes have a direct effect on science achievement (Cannon & Simpson, 1985; Schibeci & Riley, 1986), quality of classwork (Germann, 1988; Weinburg, 1995) and students' later views of science education and scientific occupations in secondary school and beyond (Brown, 1976; Smail, 1993). Research has also shown that attitudes associated with science to be affecting student participation in science as a subject (AAAS, 1989; Koballa, Crawley, & Shrigley, 1990) and this has high bearing on Malaysian 60:40 Policy to favour more participation in science-based subjects among secondary students. Gray (1996) points out that it is a mistake to omit attitudinal measures in any evaluation of school science. Thus, with a proposed doctoral study that aims to investigate the impact of an innovation within a Malaysian context, attitude towards science has been identified as one of the dependent variables. As such, a pilot study was carried out to validate a translated version of an attitudinal instrument which would ultimately be used in the principal study.

THE CONCEPT OF ATTITUDES

The term 'attitude' encompasses a wide range of affective behaviour (e.g., prefer, appreciate), and is used loosely, which has led to considerable confusion. Whereas Shrigley, Koballa, and Simpson (1988) point out the struggle among science educators for consensus definition of science attitudes, Koballa (1989) highlights the difficulties in differentiating attitudes with other related concepts such as beliefs and values. Hence, the relevance of reviewing the literature for the varied meanings of attitude.

Ormerod (1973: 645) defines attitude in a educational context as "a state of preparedness or predisposition to learn or not to learn." Brown (1976) views attitude as made up of three components: the affective (feelings, emotions), the cognitive (beliefs, knowledge) and the behavioural (predisposition to respond in a particular way). She exemplifies this by considering a pupil who has adopted an attitude of "objectivity in the collection of scientific data." Such a pupil will have come to prefer (affective) to be objective in making observations, to have knowledge or beliefs (cognitive) about what this entails, and actually to carry out (behavioural his experiments in that way. Oppenheim (1992) shares a similar view when he defines attitude to be "a state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli" (p. 174). Such an attitude, he states, is "reinforced by *beliefs* (he cognitive component) and often attracts strong *feelings* (the emotional component) which may lead to particular behavioural *intents* (the action tendency component)" (p. 175) [emphases by the author]. Such a conceptualisation of attitude as a tripartite (affection, cognition, and action) has also been proposed by Krech, Crutchfield, and Ballackey (1962) who embraced the notion of attitude as having three distinct components: the affective, the behavioural, and the cognitive.

Fishbein and Ajzen (1975) describe attitude as "a learned predisposition to respond to a stimulus in a consistently favourable or unfavourable manner with respect to a given object" (p. 6) and that the "predisposition to respond in consistently favourable or unfavourable ways are assessed to be the results of past experiences" (p. 10). In Ajzen and Fisbein's (1980) theory of reasoned action, attitude is solely evaluative. To them attitude, both personal and social, is a function of belief while behavioural intention is a concept more closely related to behaviour than attitude.

Koballa (1989) contends that attitudes are our favourable or unfavourable feelings towards something and such feelings are the elements of attitudes measured by attitude instruments. He posits that attitudes are learned either actively or vicariously and therefore, can be taught. Because attitudes are learned, they are susceptible to change but stable enough to be enduring.

In summary, then, the review of literature on the meaning of attitudes identifies two camps of theorists. The first camp (i.e. Krech, Crutchfield, & Ballackey, 1962; Brown, 1976) conceptualises attitude as embracing three distinct components: the affective: the behaviour and the cognitive. The second camp (i.e. Fishbein & Ajzen, 1975; Koballa, 1989), by contrast, maintains that attitude measurement should be concerned solely with the affective domain, and that the behaviour and cognitive components should be assessed separately.

ATTITUDES TOWARDS SCIENCE

From the above examination, it can be seen that the term attitude is open to a number of interpretations. Gardner (1975) acknowledges the broad nature of the term attitude that takes on different meanings in discussions about science education. He distinguishes two broad categories of attitude. The first category, "attitudes towards science" (e.g. interest in science, attitudes towards scientist, attitudes towards social responsibility in science) shows some distinct attitude object such as science or scientist, to which the respondent is invited to react favourably or otherwise. The second category, "scientific attitudes" (e.g. open-mindedness, objectivity, honesty and scepticism), by contrast, are best described as styles of thinking which scientists are presumed to display.

Ormerod and Duckworth (1975) concur with such a distinction when they maintain that, "it is important to distinguish between those studies which investigate what can be described as a global attitude or disposition of mind for or against scientists and scientific activity, and other studies which are devoted to the identification or assessment of those desirable scientific attitudes—regard for evidence, thoroughness, attention to detail..."(p. 6).

The first of Gardner's (1975) two categories concentrates on the emotional reaction that students might be expected to show towards science. It is on these emotional responses rather than more intellectual aspects developed through the study of science that are of interest. In this respect, Gardner regards attitudes to science as "learned disposition[s] to evaluate in certain ways objects, actions, situations or propositions involved in the learning of science" (ibid., p. 2).

INSTRUMENT FOR VALIDATION

When attempting to revise an instrument, Munby (1997) recommends that account should be taken of previous studies, which have recently used the pertinent instrument and this includes the "reporting on reliability and information pertaining to validity" (p. 340). As such, this section explains the choice for selecting a particular instrument and reviews the previous studies done on it.

Attitude measurement in this study adopts the view of the second camp that defines attitude as "the affect for or against a psychological object" (Thurstone, 1931, p. 261) and that beliefs and behavioural intentions are determinants of attitude (Fishbein & Ajzen, 1975). Therefore, the "Attitude towards Science in School Assessment" (henceforth referred to as ATSSA) instrument, developed by Germann (1988) and translated into the Malay Language by Lau (1997) is reviewed for further validation.

Germann's (1988) ATSSA is selected because it attempts to measure a single dimension of general attitude towards science. More specifically, it gauges the degree to which students like or enjoy science as a subject in school; not any specific science courses (i.e., lecture, classroom, group work, homework or fieldtrip) that occur within science classes. In this perspective, attitude does not include scientific attitudes, attitudes towards scientists, towards methods of teaching science, or towards scientific interests. Nor does it include judgements of personal ability in science, the value of science to the individual, or the value of science to society.

Originally, there were 34 items, which Germann (1988) sourced from a variety of instruments that purported to assess attitude. However, the list was reduced to 24 items based on the evaluation for construct validity by a panel of three judges. Using a 5-point Likert Scale, it was then pilot tested with 125 grades 7 and 8 students. On a possible minimum score of 24 and a maximum score of 120, Germann's (1988) pilot study generated a mean of 85.7 (SD=13.4) with a range from 40 to 114. Cronbach's alpha reliability was 0.93. Item-total correlations ranged from 0.13 to 0.83.

When submitted to principal-component factor analysis, fourteen items were found to have loadings greater than 0.40 on a factor that best fit the desired construct of general attitude towards science. These 14 items (see Appendix) were then further field tested in four studies that taken together involved 492 students. Cronbach's alpha estimates of reliability were all greater than 0.95, indicating an acceptable level of internal reliability. In all the four studies, all the 14 items were loaded on only one factor with constant factor loading and the percentages of variance accounted for by this factor were 64.9, 69.8, 67.4 and 59.2 respectively. The results from factor analysis established the unidimensionality of the 14-item ATSSA. The unidimensionality was further supported by item-total correlations that ranged between 0.61 and 0.89.

Lau (1997) translated the 14-item ATSSA and had it checked by two linguists for accuracy, suitability of reading level for 14-year-old Malaysian students, and conformity to local context. The refined version was then checked by two science graduate teachers of more than 14 years of science teaching experience. This procedure where experts are employed to judge the clarity, aims to establish the contents validity of the instruments.

For the purpose of this pilot study, the translated version used by Lau (1997) was checked by two experienced teachers, one with 15 years while the other, 20 years of experience. While maintaining the face validity and the accuracy of the translation for all the 14 items, it was pointed out that the translated terms for "Disagree" (i.e., "Kurang Setuju") and "Strongly Disagree" (i.e, "Tidak Setuju") did not correspond to the gravity of disagreement in the original version. In its literal sense, the prefix of "Dis-" was translated to "Kurang" which means "Less" while for "Strongly Dis-" it was "Tidak" which means "Not". Both teachers agreed that "Dis-" and "Strongly Dis-"should be better worded as "Tidak" and "Sangat Tidak" respectively. Appendix shows the refined Malay version of ATSSA [henceforth referred to as ATSSA(M)]

In Lau's (1997) study, Cronbach's alpha was found to be 0.87, indicating a satisfactory level of internal consistency. The item-total correlations of all the items in the translated version of ATSSA were all significant at $p<.001$ with values that ranged from 0.47 to 0.70. However, factor analysis was not computed to establish the unitary validity.

Munby (1997) maintains that it is desirable to invest in unitary validity or construct validity (Cronbach, 1984; Messick, 1989) other than the panel of experts (or judges) technique that relies on a tenuous assumption: that the meanings test items have for judges are in some way equivalent to those held by students who are to take the test (Munby, 1982). This technique of using experts or judges is recognised as insufficient in validation (American Psychological Association, 1985). Munby (1997) recommends researchers to take the options of "factor analysis or cluster analysis to determine the fit of the conceptually derived scales with empirically derived factors or clusters,...[or] independent conceptual analysis of the instrument's items,...[or] an analysis of information from the instrument's use in other studies" (p. 338). With this recommendation, a pilot study was carried out to establish the reliability and validity, particularly the unidimensionality, of ATSSA(M).

THE PILOT STUDY

The aim of the pilot study was to establish the reliability and validity, particularly the unidimensionality of the 14-item ATSSA(M)—the Malay version of ATSSA. A undimensional scale, according to De Vaus (2001) is "one in which each item measures the same underlying concept" (p. 255). If the items were measuring the same concept, then "responses to a particular item [would] reflect the pattern of responses on other items" (ibid, p. 255). To determine this, he proposes that item-total correlations to be calculated, discarding items that yield correlations less than 0.3. A further test for unidimensionality should then be done with factor analysis—a view shared by Gardner (1975, 1996). In this article, "The dimensionality of attitude scales: a widely misunderstood idea", Gardner (1996) presents six case studies that display the following flaws: complete neglect of dimensionality, conceptualisation without considering dimensionality, and available evidence about dimensionality ignored. He argues that failure to meet the unidimensionality of a scale, which is central assumption underpinning summated rating scales, would produce meaningless and uninterpretable data.

Sample

A secondary school in the Larut Matang District in the State of Perak was chosen for pragmatic reasons, such as accessibility without much bureaucratic difficulty. However, verbal permission was sought from the school principal, and the she approved with a condition that the school would be identified. Since the classes were streamed, one class from each of the three bands (i.e., high, average, and low ability) was chosen on the assumption that these students are representative of the cohort of students in that school. There were 40 students in each of the three Form 3 classes, making a total of 120 Form 3 students (i.e., age 15) for this study.

The responses of 120 students on ATSSA(M) sent by the teacher who administered the instrument in June 2002 and coded the responses in the Microsoft Word programme were transferred into SPSS and recoded for twelve items, namely 1, 3, 4, 5, 6, 8, 9, 11, 12 and 13. These items, which were all positive statements, needed recoding because the coded values of 1, 2, 4 and 5 for 'Strongly Agree', 'Agree', 'Disagree', and 'Strongly Disagree' respectively, were in fact in the reverse order. In recoding, the old values of 1, 2, 4, and 5 were changed to 5, 4, 2 and 1 correspondingly to reflect the appropriate point value. ATSSA(M) was re-administered in July 2002, after a 4-week interval, to establish the degree of consistency of the scale over time (i.e., external reliability) gauged by the correspondence between the two waves of measurement.

Results

On a possible minimum score of 14 and a maximum score of 70, this pilot study generated a mean score of 56.8 and individual scores ranging from 31 to 70. This shows that the ATSSA(M) displays adequate sensitivity since the scores of 120 students in the sample covered more than two-thirds (i.e. 70%) of the potential range of the scale.

For test-retest reliability, the Pearson Product-Moment correlation coefficient of the totals on the two occasions was 0.93, suggesting that the scale has high external reliability in that it yielded almost similar scores when applied to the same individuals at different times. Cronbach's alpha reliability was measured at 0.90, which can be claimed as a high value and indicating that the items have high internal consistency.

As shown in Table 1, the item-total correlations (r), ranging from 0.48 to 0.77, are all above 0.3, signifying that the 14 items seem to form part of a unidimensional scale for attitudes towards science. Additionally, items with r values of 0.3 are considered to discriminate well (e.g., discriminating between students with negative attitudes towards science and those with positive ones) and this is reinforced by sufficient variability shown with standard deviations ranged from 0.62 to 1.03, with a pooled SD of 8.11.

Table 1
Means, standard deviations, item-total correlations of scale items

Item	Means	SD	Item-total correlations
1	4.18	0.79	0.76*
2	4.08	0.87	0.70*
3	4.20	0.77	0.73*
4	4.43	0.62	0.49*
5	3.54	1.03	0.46*
6	4.06	0.87	0.73*
7	4.09	0.94	0.67*
8	4.06	0.91	0.72*
9	4.07	0.82	0.69*
10	4.04	1.02	0.48*
11	4.11	0.82	0.77*
12	3.93	0.88	0.74*
13	4.00	0.77	0.70*
14	4.09	1.08	0.71*

* correlation is significant at the 0.01 level (2-tailed)

The correlation matrix for the 14 items, together with their levels of significance, is presented in Table 2. All but two of the items are significantly positively correlated at less than the 0.05 significance level, which suggests that they are related and that "they may constitute one or more factors" (Bryman & Cramer, 1998, p. 279).

When subjected to principal components factor analysis, a two-factor solution seems to emerge on the basis of eigenvalues as depicted in Table 3.

An eigenvalue is a "measure that attaches to factors and indicates the amount of variance in the pool of original variables [or items in this case] that the factor explains...[land] to be retained, factors must have an eigenvalue greater than 1" (De Vaus, 2001, p. 261). While Factor 1 has an eigenvalue of 6.43 and accounts for 45.9 per cent of the total variance, Factor 2 carries an eigenvalue of 1.09 which is close to 1 and accounts for only 7.8 per cent of the total variance.

Table 2
Correlation Matrix

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Correlation	Q1	1.000	.620	.620	.275	.265	.525	.477	.574	.440	.210	.625	.530	.499	.484
	Q2	.620	1.000	.514	.220	.206	.492	.543	.471	.477	.241	.484	.425	.381	.455
	Q3	.620	.514	1.000	.362	.283	.468	.458	.473	.471	.223	.563	.565	.408	.509
	Q4	.275	.220	.362	1.000	.195	.451	.219	.343	.325	.104	.305	.395	.368	.279
	Q5	.265	.206	.283	.195	1.000	.169	.129	.331	.245	.177	.337	.364	.288	.172
	Q6	.525	.492	.468	.451	.169	1.000	.483	.451	.466	.308	.580	.532	.468	.509
	Q7	.477	.543	.458	.219	.129	.483	1.000	.414	.428	.379	.423	.373	.423	.435
	Q8	.574	.471	.473	.343	.331	.451	.414	1.000	.537	.205	.533	.447	.449	.471
	Q9	.440	.477	.471	.325	.245	.466	.428	.537	1.000	.268	.517	.534	.433	.410
	Q10	.210	.241	.223	.104	.177	.308	.379	.205	.268	1.000	.296	.218	.312	.352
	Q11	.625	.484	.563	.305	.337	.580	.423	.533	.517	.296	1.000	.596	.489	.491
	Q12	.530	.425	.565	.395	.364	.532	.373	.447	.534	.218	.596	1.000	.585	.413
	Q13	.499	.381	.408	.368	.288	.468	.423	.449	.433	.312	.489	.585	1.000	.489
	Q14	.484	.455	.509	.279	.172	.509	.435	.471	.410	.352	.491	.413	.489	1.000
Sig. (1-tailed)	Q1		.000	.000	.001	.002	.000	.000	.000	.000	.011	.000	.000	.000	.000
	Q2	.000		.000	.008	.012	.000	.000	.000	.000	.004	.000	.000	.000	.000
	Q3	.000	.000		.000	.001	.000	.000	.000	.000	.007	.000	.000	.000	.000
	Q4	.001	.008	.000		.017	.000	.008	.000	.000	.129	.000	.000	.000	.001
	Q5	.002	.012	.001	.017		.032	.080	.000	.004	.027	.000	.000	.001	.030
	Q6	.000	.000	.000	.000	.032		.000	.000	.000	.000	.000	.000	.000	.000
	Q7	.000	.000	.000	.008	.080	.000		.000	.000	.000	.000	.000	.000	.000
	Q8	.000	.000	.000	.000	.000	.000	.000		.000	.012	.000	.000	.000	.000
	Q9	.000	.000	.000	.000	.004	.000	.000	.000		.002	.000	.000	.000	.000
	Q10	.011	.004	.007	.129	.027	.000	.000	.012	.002		.001	.008	.000	.000
	Q11	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001		.000	.000	.000
	Q12	.000	.000	.000	.000	.000	.000	.000	.000	.000	.008	.000		.000	.000
	Q13	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000		.000
	Q14	.000	.000	.000	.001	.030	.000	.000	.000	.000	.000	.000	.000	.000	

Table 3
Total Variance Explained

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	6.432	45.944	45.944
2	1.092	7.797	53.741
3	.936	6.686	60.427
4	.892	6.375	66.802
5	.641	4.576	71.378
6	.607	4.338	75.716
7	.591	4.222	79.938
8	.558	3.985	83.923
9	.508	3.628	87.551
10	.447	3.193	90.744
11	.419	2.995	93.738
12	.326	2.329	96.068
13	.293	2.095	98.163
14	.257	1.837	100.000

Extraction Method: Principal Component Analysis.

Looking at the component or factor matrix shown in Table 4, all the 14 items are found to load on Factor 1 with factor loadings (or correlations) greater than 0.4. However, the pattern of loadings of questions (items) 4, 5 and 10 suggests that these items are 'noisy' in that they all load relatively weakly on the first factor but strongly on the second factor whereas their intercorrelations, as shown in Table 2, are relatively low ranging from 0.104 to 0.195, casting doubt on this as a coherent factor. Their relatively low item-total correlations (i.e., 0.49, 0.46, and 0.48 respectively), as shown in Table 1, seem to confirm this. De Vaus (2001) views any item which loads on more than one factor as contaminant and gives the advice to "drop it from the factor analysis" (p. 264).

Table 4
Component Matrix

	Component	
	1	2
Q1	.781	-.003
Q2	.709	-.245
Q3	.749	.006
Q4	.499	.405
Q5	.408	.518
Q6	.744	-.007
Q7	.662	-.441
Q8	.721	.121
Q9	.704	.004
Q10	.424	-.478
Q11	.784	.008
Q12	.752	.289
Q13	.703	.008
Q14	.695	-.233

Extraction Method: Principal Component Analysis.
[a]2 components extracted.

As shown in Table 5, when the 11 remaining items (with items 4, 5 and 10 removed from the list) were subjected to principal components factor analysis, only one factor solution was generated with an eigenvalue of 5.91 which accounted for 53.73 per cent of the total variance.

Table 5
Total Variance Explained

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	5.910	53.729	53.729
2	.790	7.179	60.908
3	.665	6.045	66.954
4	.626	5.691	72.644
5	.592	5.381	78.025
6	.537	4.883	82.908
7	.508	4.621	87.529
8	.434	3.944	91.473
9	.365	3.318	94.792
10	.307	2.790	97.582
11	.266	2.418	100.000

Extraction Method: Principal Component Analysis.

Looking at the component or factor matrix shown in Table 6, all the 11 items are found to load highly on Factor 1 with factor loadings greater than 0.6. This clearly indicates the scale's homogeneity in that the 11-item ATSSA(M) measures a single dimension of a general attitude towards science, specifically, how students feel towards science as a subject in school.

Table 4
Component Matrix[b]

	Component
	1
Q1	.800
Q2	.727
Q3	.754
Q6	.742
Q7	.671
Q8	.722
Q9	.706
Q11	.788
Q12	.747
Q13	.694
Q14	.700

Extraction Method: Principal Component Analysis.

[b]1 component extracted.

CONCLUSION

The results presented suggest that the ATSSA(M)—the Malay version of Germann's (1988) Attitudes Towards Science in School Assessment (ATSSA) is valid and reliable for use with secondary students, particularly students at Form 3 (age 15) in the Malaysian context who would be participating in the principal study. Furthermore, the findings also suggest that the scale (see Appendix), when reduced to 11 items from 14, is a useful and more parsimonious instrument for the evaluation of students' attitudes towards science. Finally, the results provide the psychometric evidence that justifies the use of summated-ratings procedure to measure students' attitudes towards science.

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APPENDIX

Soal selidik sikap terhadap sains

Diterjemahkan dari: Attitude toward Science in School Assessment (ATSSA) (German, 1988, p. 701)

Nama: ________________________ (Lelaki / Perempuan)

Tingkatan: ______________________

Soal Selidik ini mengandungi pernyataan tentang sikap anda terhadap sains.

Tanda (√) pada ruang yang disediakan mengikut skala yang berikut:

SS : Sangat Setuju *(Strongly Agree)*

B : Bersetuju *(Agree)*

N : Tidak Pasti sama ada Bersetuju atau Tidak Bersetuju *(Neither Agree nor Disagree)*

TB : Tidak bersetuju *(Disagree)*

STB : Sangat Tidak Bersetuju *(Strongly Disagree)*

		SS	B	N	TB	STB
1.	Sains menyeronokkan *(Science is fun)*					
2.	Saya tidak suka sains dan saya rasa mempelajari sains sesuatu yang menyusahkan. *(I do not like science and it bothers me to have to study it)*					
3.	Saya berminat mengikut kelas sains. *(During science class, I usually am interested)*					
*4.	Saya ingin mengetahui dengan lebih mendalam mengenai sains. *(I would like to learn more about science)*					

*5.	Jika saya diberitahui bahawa saya tidak akan menghadiri kelas sains lagi, saya akan rasa sedih. *(If I knew, I would never go to science class again, I would feel sad)*	
6.	Sains adalah menarik dan saya dapat menikmati mata pelajaran tersebut. *(Science is interesting to me and I enjoy it)*	
7.	Sains membuat saya tidak selesa, gelisah, resah dan tidak sabar. *(Science makes me feel uncomfortable, restless, irritable, and impatient)*	
8.	Sains mengagumkan dan menyeronokkan. *(Science is fascinating and fun)*	
9.	Perasaan saya terhadap sains adalah perasaan yang baik. *(The feeling that I have towards science is a good feeling)*	
*10.	Apabila mendengar perkataan sains, saya ada perasaan tidak suka. *(When I hear the word science, I have a feeling of dislike)*	
11.	Sains adalah satu mata pelajaran yang seronok saya pelajari. *(Science is a topic which I enjoy studying)*	

12.	Saya rasa selesa dengan sains dan saya sangat suka akan mata pelajaran tersebut. *(I feel at ease with science and I like it very much)*	
13.	Saya mempunyai reaksi yang amat positif terhadap sains. *(I feel a definite positive reaction to science)*	
14.	Sains mejemukan *(Science is boring)*	

* Shaded items are items which would be dropped from the refined version of ATSSA (M)