Chemistry Education Research and Practice

PAPER

Quantifying attitude to chemistry in students at the University of the South Pacific

Cite this: *Chem. Educ. Res. Pract.*, 2014, **15**, 184

S. J. Brown,*[ab] B. N. Sharma,[c] L. Wakeling,[b] M. Naiker,[b] S. Chandra,[c] R. D. Gopalan[c] and V. B. Bilimoria[d]

Received 1st December 2013, Accepted 21st February 2014

DOI: 10.1039/c3rp00155e

www.rsc.org/cerp

The attitude towards the study of chemistry for new entrant chemistry students from a multi-national, regional, tertiary educational institution in the South Pacific was investigated using a purpose-designed diagnostic instrument. The Attitude toward the Study of Chemistry Inventory (ASCI) was used to quantify attitude in a cohort of first year undergraduate (n = 144) and foundation (n = 108) chemistry students. A similar, generally positive attitude to the study of chemistry was shown by both groups of students. Exploratory factor analysis using principle axis factoring and direct oblimin rotation was used to identify factors within the pooled data. Three factors accounted for more than 50% of the total variance, while Cronbach's alpha values for the factors 1, 2 and 3 were 0.92, 0.68 and 0.78, respectively. Factors 1 and 2 were consistent with known constructs of attitude, namely affective (factor 1) and cognitive (factor 2). However, the other factor (3) identified in this study was designated "Value", which may reflect the students' choice of chemistry as a career path. ASCI may be a suitable tool for monitoring students' attitude throughout a degree and also to monitor the impact of novel approaches for teaching chemistry and engaging students.

Introduction

Undergraduates are required to develop an understanding of subject specific content, and both the delivery and assessment of this content knowledge is supported by an extensive body of teaching and learning pedagogy. However, students' attitude to this content is rarely measured, yet a positive attitude may be congruent with higher achievement (Osborne *et al.*, 2003; Xu and Lewis, 2011; Xu *et al.*, 2012). Thus, it would seem appropriate to quantify attitude to chemistry during an undergraduate chemistry degree (Berg, 2005; Bauer, 2008), as this would complement the regular assessment of content specific knowledge.

The promotion of positive attitudes towards chemistry is an important component of an undergraduate chemistry degree, yet the concept of an attitude towards chemistry is somewhat nebulous, often poorly articulated and not well understood. Attitude can be considered as a tendency to respond to a certain stimulus (in this instance, chemistry), where the response has cognitive, affective, and behavioural elements, thus forming a tripartite theoretical model of attitude (Rosenberg and Hovland, 1960). The 'affective' reflects emotional responses through individual preferences to the stimulus, the 'cognitive' reflects an individual's beliefs and knowledge about the stimulus, and the 'behavioural' reflects an individual's tendency to act in a particular manner regarding the stimulus. Others (Bagozzi and Burnkrant, 1979) proposed that attitude could be viewed as a two component construct comprised of a cognitive and an affective component. These two attitudinal dimensions may simultaneously account for behavioural predispositions, although they may also have a differential impact on them.

The tripartite view of attitude (Rosenberg and Hovland, 1960) suggests that there is a clear distinction between thoughts, emotions, and behavioural intentions associated with a particular attitude. Thus, attitude to chemistry (or to science in general) may be identified and quantified within this tripartite structure, but only if appropriate instruments are used which identify these constructs. However, the tripartite view of attitudes requires cognitive, affective, and behavioural responses which are consistent (Fazio and Williams, 1986), suggesting that a single instrument may be inadequate for quantifying such a multi-dimensional phenomenon (Adams and Wieman, 2010). Somewhat simplistically, attitude can be summarised as being positive or negative. However, attitude also has characteristics such as importance, certainty, and accessibility (Visser *et al.*, 2006) – this inter-attitudinal structure may connect different sub-constructs of attitudes to one another, and/or to more underlying psychological constructs,

[a] *School of Interprofessional Health Studies, AUT, Auckland, New Zealand*
[b] *School of Health Sciences, Federation University, University Drive, Mount Helen, VIC3350, Australia. E-mail: sj.brown@federation.edu.au*
[c] *School of Biological and Chemical Sciences, Faculty of Science, Technology and Environment, University of the South Pacific, Laucala Campus, Suva, Fiji*
[d] *College of Foundation Studies, University of the South Pacific, Laucala Campus, Suva, Fiji*

for example values. Therefore, an instrument to quantify attitude to the study of chemistry may potentially have factors within it which align to this inter-attitudinal structure.

Teaching pedagogy aimed at developing a positive attitude toward science can be implemented within a curriculum. For example, debate (Shaw, 2012), educational games (Akl *et al.*, 2013), role play (Koponen *et al.*, 2012), and practical experience (Freedman, 1997; Abdullah *et al.*, 2009) have all been used to develop positive attitudes toward the study of chemistry. However, in order to quantify the possible influence these pedagogies have on attitude toward chemistry in an undergraduate curriculum, appropriate and valid instruments which measure attitude are required. The Chemistry Expectations Survey (CHEMX; Grove and Bretz, 2007), Chemistry Attitudes and Experiences Questionnaire (CAEQ; Coll *et al.*, 2002), and the Colorado Learning Attitudes about Science Survey (CLASS; Barbera *et al.*, 2008; Heredia and Lewis, 2012) are validated tools that have been used to quantify attitude to chemistry in undergraduate students. Also, the Attitudes to the Study of Chemistry Inventory (ASCI: Bauer, 2008; Xu and Lewis, 2011), and its more recent shortened version ASCIv2 (Xu *et al.*, 2012) may also be suitable tools to quantify attitudes to chemistry in undergraduate students.

The University of the South Pacific (USP) is a regional university operating since 1968. Owned by 12 member countries, it is supported through 14 campuses spread over an area of 30 million square kilometers of the Pacific Ocean, with 20 000 students enrolled (Jokhan and Sharma, 2010; Sharma *et al.*, 2011). The smaller centers are part of the larger campuses spread in remote locations or on the smaller islands in some countries. This geographical spread, student diversity, shoestring budgets, varying teaching resources and inherent limitations necessitate the adoption and adaptation of efficient, cost effective learning and teaching tools and technologies, and a culture-inclusive curriculum for the region (Chandra, 2012). While the University has students coming directly from seconday school, there is a growing percentage (>30%) of mature students joining or rejoining USP in recent years.

The College of Foundation Studies at USP offers two programmes at the pre-degree level: the Preliminary Programme and the Foundation Programme in Science and Social Science. The Foundation Science Program aims to enhance students' theoretical, problem solving, practical/experimental skills, and research and teamwork skills and equip students for studies in the degree level at USP or at any other tertiary institute. Students entering the Foundation Programme will normally have passed an approved Form 6 examination (or equivalent), or have completed a USP Preliminary Programme. Students enrol in either the Foundation Science Programme or the Foundation Social Science Programme, depending on the subjects they studied at secondary school (or in the Preliminary Programme) and also the degree programme they want to pursue once they complete their foundation studies. A total of 8 courses are required for admission to first year undergraduate studies at USP from the full Foundation Science Programme. To complete the Foundation Science Programme over two semesters, students must pass two English language courses, plus a further six foundation science courses related to agriculture, biology, chemistry, computing, geography, mathematics, physics, and technology.

The ASCI has not been used to quantify attitude to chemistry in a mixed cohort of both first year undergraduate chemistry majoring students and Foundation science students studying chemistry at the university. Also, the unique geography, demography, and language diversity of the Pacific Islands region, and the key role of USP as a regional provider of science education at a tertiary level in this region, provide a unique cohort in which to quantify attitude to chemistry. Therefore, the aim of the current study was to quantify the attitude toward the study of chemistry, using the ASCI instrument, in a cohort of first year undergraduate and foundation chemistry students at the University of the South Pacific.

Methods

With the ethics committee approval, the Attitude toward the Study of Chemistry Inventory (ASCI, see Fig. 1) was given to two groups of students enrolled at the University of the South Pacific in 2013. First year undergraduate students studying chemistry at USP were recruited into the study during their first semester of study. ASCI was administered on-line using Survey Monkey©, and completed by 144 students. ASCI was also administered (in paper format) to 108 foundation year chemistry students in their first semester of study. Respondents in both groups were given clear instruction about completing the inventory, and given approx. 20 min to complete it. All data were collected anonymously and without individual identification. Data were transferred to both Excel and SPSS (IBM SPSS Statistics 19).

Exploratory factor analysis was carried out on the combined data from both groups. The internal structure of all data (total number of responses = 252) was assessed using the principal axis factoring method with the direct oblimin rotation method. Internal consistencies of items loaded onto each identified subscale were estimated using Cronbach's α.

Results

Responses to ASCI

Each group of students' responses to the ASCI are summarised in box-and-whisper plots, as shown in Fig. 2. For both foundation students and first year undergraduate students, a generally positive attitude toward the study of chemistry was measured. Highest positive scoring items were for 'beneficial', 'good', 'interesting', and 'worthwhile', whereas items which suggested a 'negative attitude' in both groups were: complicated–simple; challenging–not challenging; work–play; tense–relaxed. For the Foundation year students (n = 108), the mean (SD) scores for factor 1, 2 and 3 were 31.4 (11.6), 19.8 (4.8), and 25.4 (5.3) respectively. For the first year undergraduates (n = 144), the mean (SD) scores for factor 1, 2, and 3 were 29.0 (12.9), 18.7 (5.8), and 25.7 (5.8). For each factor, a two sample equal variance Student's t-test was used to compare these values

CHEMISTRY IS:

1.	easy	1 2 3 4 5 6 7	hard
2.	worthless	1 2 3 4 5 6 7	beneficial
3.	exciting	1 2 3 4 5 6 7	boring
4.	complicated	1 2 3 4 5 6 7	simple
5.	confusing	1 2 3 4 5 6 7	clear
6.	good	1 2 3 4 5 6 7	bad
7.	satisfying	1 2 3 4 5 6 7	frustrating
8.	scary	1 2 3 4 5 6 7	fun
9.	comprehensible	1 2 3 4 5 6 7	incomprehensible
10.	challenging	1 2 3 4 5 6 7	not challenging
11.	pleasant	1 2 3 4 5 6 7	unpleasant
12.	interesting	1 2 3 4 5 6 7	dull
13.	disgusting	1 2 3 4 5 6 7	attractive
14.	comfortable	1 2 3 4 5 6 7	uncomfortable
15.	worthwhile	1 2 3 4 5 6 7	useless
16.	work	1 2 3 4 5 6 7	play
17.	chaotic	1 2 3 4 5 6 7	organized
18.	safe	1 2 3 4 5 6 7	dangerous
19.	tense	1 2 3 4 5 6 7	relaxed
20.	insecure	1 2 3 4 5 6 7	secure

Fig. 1 Items in the Attitude to the Study of Chemistry Inventory (ASCI).

between the two populations, with no significant differences being recorded (all $P > 0.1$).

Exploratory factor analysis (EFA)

Both groups' responses to ASCI were pooled for the exploratory factor analysis – this decision was based on the similarity of the mean responses to each item for both groups. The Kaiser–Meyer–Olkin (KMO, a measure of sampling adequacy) was 0.895, and Bartlett's test of sphericity was < 0.001. An initial three factor solution, based on eigenvalues >1, was suggested, where factors 1, 2, and 3 had eigenvalues of 7.635, 2.327, and 1.296, respectively. These 3 factors accounted for 56.3% of the total variance. Cronbach's α was used as a statistic to indicate the internal consistency of the items which contribute to the factor (Cronbach, 1951; Cortina, 1993); for factors 1, 2, and 3 the values were 0.92, 0.68, and 0.78, respectively. The pattern matrix for items and extracted factors is shown in Table 1, and the structure matrix is shown in Table 2. The correlation between factor 1 and 3 was −0.607, suggesting some interdependence between these factors.

Discussion

This is the first study to quantify the attitude to the subject of chemistry in students of chemistry at a university in the Pacific Islands. This study attempts to quantify the attitude to the study of chemistry using an established instrument (ASCI), and its uniqueness is that the population of interest is from a diverse, multi-lingual region, unified by enrolment at the dominant higher education provider within the region (USP). We also used the EFA statistical procedure to indicate a three factor internal data structure – a different finding to previous reports using the same ASCI instrument. The present study is exploratory only, and does not attempt to validate the instrument. Further work, to include confirmatory factor analysis, is proposed to examine the 'fit' of the three factor solution to this cohort.

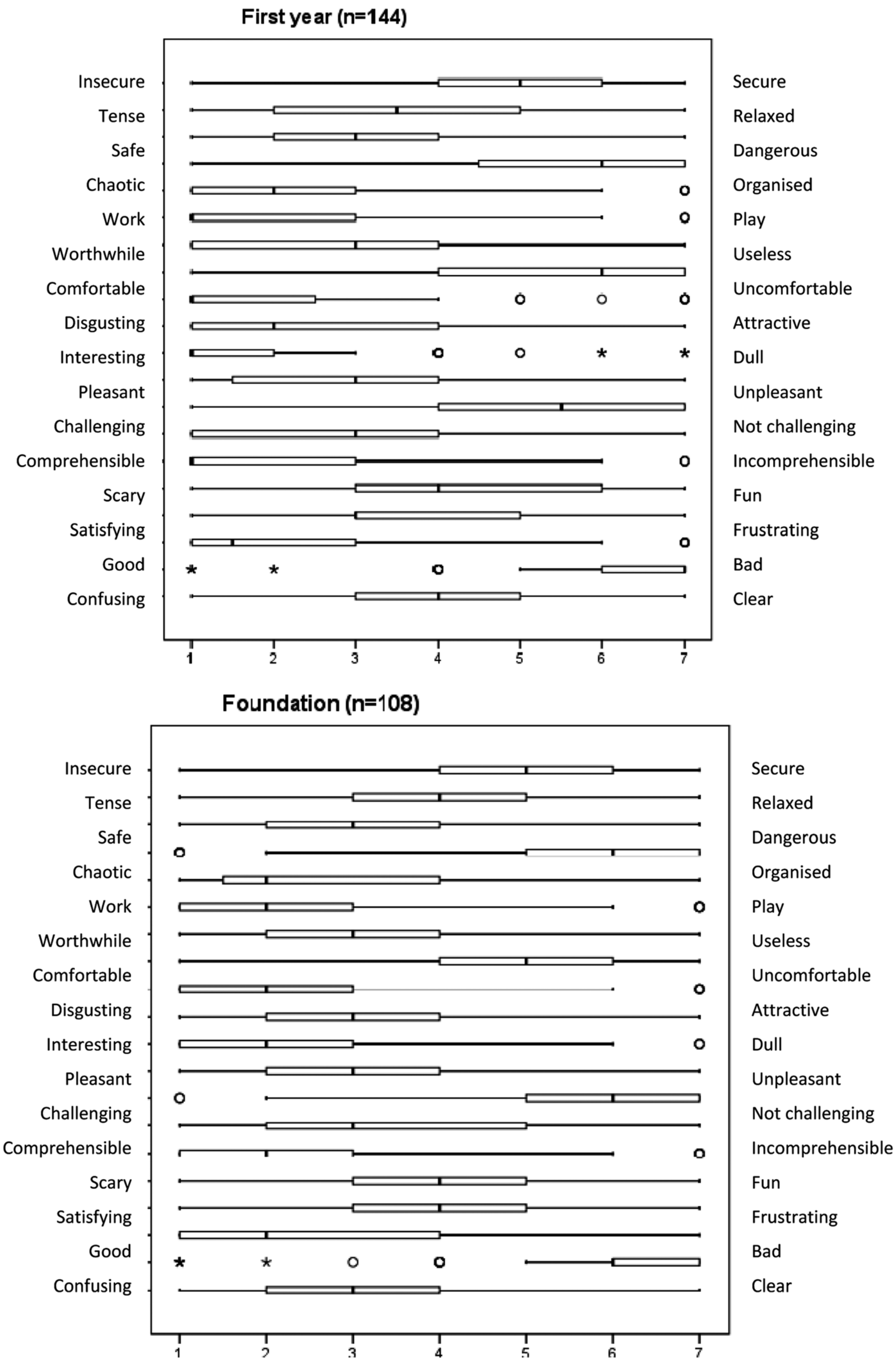

Fig. 2 Responses to the Attitude to the Study of Chemistry Inventory (ASCI) in first year (upper figure) and foundation year (lower figure) students at the University of the South Pacific. The figure shows box-and-whisper plots for each ASCI item, where the upper and lower limits to the box are the values for the 1st and 3rd quartiles, respectively, the line in the box indicates the 2nd quartile, and the limits of the whiskers are the minimum and maximum values. Outliers are indicated by 'o' and 'x'.

The ASCI was originally validated in the United States on undergraduates majoring in chemistry (Bauer, 2008). Using exploratory factor analysis, Bauer (2008) reported a four factor solution, with items aligning to factors described as: Interest/Utility (5 items); Emotional Satisfaction (4 items); Anxiety (4 items); and Intellectual Accessibility (5 items). A single item (safe–dangerous) was independent of the other four factors, and was described with the term 'Fear'. In the current study, factor one contained 4 items previously identified as Interest/Utility, 3 items as Emotional Satisfaction, 2 items previously identified as Intellectual Accessibility, and two further items previously identified as Anxiety and Fear, respectively. Thus, the current study indicated that this collection of items represented a common factor, and we suggest that a suitable

Table 1 Pattern matrix for Attitude to the Subject of Chemistry Inventory (ASCI) for data obtained from 252 chemistry students at The University of the South Pacific. Extraction method: principal axis factoring; rotation method: direct oblimin with Kaiser normalization (rotation converged in 9 iterations). Key: IU: interest/utility; ES: emotional satisfaction; IA: intellectual accessibility; A: anxiety; F: fear. Factor correlations were −0.052 between factors 1 and 2, −0.607 between factors 1 and 3, and 0.166 between factors 2 and 3

	Factor				
	1 α = 0.92	2 α = 0.68	3 α = 0.78	Xu and Lewis (2011)	Bauer (2008)
Comfortable–uncomfortable	0.804			Affective	ES
Pleasant–unpleasant	0.770			Affective	ES
Satisfying–frustrating	0.716			Affective	ES
Exciting–boring	0.708				IU
Worthwhile–useless	0.700				IU
Interesting–dull	0.691				IU
Good–bad	0.690				IU
Comprehensible–incomprehensible	0.678				IA
Easy–hard	0.536			Cognitive	IA
Work–play	0.465				A
Safe–dangerous	0.339				F
Tense–relaxed		0.549			A
Complicated–simple		0.538	0.330	Cognitive	IA
Challenging–not challenging		0.537		Cognitive	IA
Confusing–clear		0.352		Cognitive	IA
Scary–fun		0.324			A
Worthless–beneficial			0.748		IU
Disgusting–attractive			0.692		A
Insecure–secure			0.610		A
Chaotic–organised			0.568	Affective	ES

Table 2 Structure matrix for Attitude to the Subject of Chemistry Inventory (ASCI) for data obtained from 252 chemistry students at The University of the South Pacific. Extraction method: principal axis factoring, rotation method: direct oblimin with Kaiser normalization

	Factor		
	1	2	3
Interesting–dull	0.811		−0.598
Pleasant–unpleasant	0.808		−0.529
Comfortable–uncomfortable	0.801		−0.489
Worthwhile–useless	0.766		−0.515
Satisfying–frustrating	0.745		−0.492
Good–bad	0.736		−0.482
Exciting–boring	0.733		−0.466
Comprehensible–incomprehensible	0.685		−0.423
Easy–hard	0.492		
Work–play	0.469		
Safe–dangerous	0.361		
Complicated–simple	−0.378	0.600	0.510
Tense–relaxed		0.577	
Challenging–not challenging		0.511	
Worthless–beneficial	−0.439		0.714
Disgusting–attractive	−0.430		0.708
Chaotic–organised	−0.514		0.676
Insecure–secure	−0.354		0.616
Confusing–clear	−0.473	0.418	0.534
Scary–fun	−0.476	0.391	0.533

descriptor for this factor could be ''Interest, Utility, and Emotional Satisfaction''. Cronbach's α for this factor was 0.92, suggesting good internal consistency (Bland and Altman, 1997; Sijtsma, 2009). The ASCI items which are collected under this heading may quantify the affective responses to the study of chemistry (*i.e.* How do I feel about studying chemistry?), as well as the feelings of studying something which represents an academic challenge. This may be a factor which identifies with the student who chooses to study a challenging course at a higher academic level, and enjoys the intellectual demands of a scientific discipline.

In the current study, factor two contained 3 items previously identified as Intellectual Accessibility, and 2 items previously identified as Anxiety. We suggest that a suitable descriptor for factor two could be ''Intellectual Accessibility and Anxiety''. In the current study, factor three contained two items previously identified as Anxiety, with additional items from the Interest/Utility and the Emotional Satisfaction sub-scales. The alignment of items in these three factors with the descriptive terms allocated to the items by Bauer (2008) is shown in Table 1. Cronbach's α for factors two and three were 0.68 and 0.78, respectively – thus indicating that the internal consistency of the items in these two factors is at the limit of acceptance (Cortina, 1993). However, it is likely that within the components of attitude (commonly summarised as affective, cognitive, and behavioural), items in the ASCI which form a common factor are likely to reflect different aspects of the same construct (Ajzen and Fishbein, 1980, and Tesser and Shaffer, 1990), thus reducing the consistency of responses to those items.

A shorter version of the original ASCI was developed by Xu and Lewis (2011). This shortened version (ASCIv2) contained eight of the original items in two sub-scales – each of which shared a common descriptor with that proposed by Bauer (2008). However, further refinement by Xu and Lewis considered that Intellectual Accessibility aligned to the cognitive component of attitude, and Emotional Satisfaction aligned to the affective component of attitude. The terms Affective and Cognitive, when used as descriptors for the two factor solution, were consistent with the components of attitude previously suggested (Rosenberg and Hovland, 1960). Using confirmatory factor analysis, Xu *et al.*

Table 3 Pattern and structure matrix for 11 selected items from the Attitude to the Subject of Chemistry Inventory (ASCI). Data were obtained from 252 chemistry students at The University of the South Pacific. Extraction method: principal axis factoring, rotation method: direct oblimin with Kaiser normalization

	Pattern matrix			Structure matrix		
	Factor			Factor		
	1	2	3	1	2	3
Variance explained	40.49%	15.58%	9.51%			
Comfortable–uncomfortable	0.886			0.832		−0.488
Pleasant–unpleasant	0.726			0.791		−0.550
Satisfying–frustrating	0.758			0.743		−0.473
Exciting–boring	0.731			0.729		−0.444
Worthwhile–useless	0.705			0.758		−0.497
Tense–relaxed		0.580			0.605	
Complicated–simple		0.427		−0.385	0.473	0.488
Challenging–not challenging		0.637			0.610	
Worthless–beneficial			0.736	−0.454		0.706
Disgusting–attractive			0.723	−0.450		0.733
Insecure–secure			0.500	−0.399		0.573

(2012) showed that 4 ASCIv2 items (easy–hard, complicated–simple, confusing–clear, challenging–unchallenging) could be included in the cognitive sub-scale, and that 4 items (uncomfortable–comfortable, frustrating–satisfying, unpleasant–pleasant, and chaotic–organised) could be included in the affective sub-scale. In the current study, factor one contained 3 of the Affective items, and factor three contained all 4 of the Cognitive items identified by Xu *et al.* (2012).

Although affective and cognitive sub-scales form part of the structure of the current data, aligning strongly with factor 1 and factor 2, respectively, other items in the original ASCI may describe another dimension within the construct of attitude (Panter *et al.*, 1997). In the current study, factor three contained 5 items in a sub-scale with good internal consistency ($\alpha = 0.78$). The ''positive attitude'' terms for these 5 items were simple, beneficial, attractive, secure, and organised – we suggest that a suitable descriptor for this sub-scale is ''Value''. We suggest that this may reflect a student's perception that studying chemistry has an intrinsic value, through both academic pursuit (questionnaire items: complicated/simple, organised/chaotic, and beneficial/worthless) and a career choice (questionnaire items: attractive/disgusting, and secure/insecure). This is complementary to the behaviour component of attitude such that students may choose to study chemistry as a behavioural response, where this response is directed by the desire to pursue a valued career in chemistry. Consistent with the multi-dimensional structure of attitude, items within factor 3 may quantify the notion of studying a difficult course that will bring both emotional and cognitive satisfaction. It may also reflect a student's desire to be challenged by the academic rigor of a university course in chemistry, and through achievement, gain social status.

To further analyse the internal structure of the data, the EFA was re-run using a selection of terms identified by the initial 3 factor solution. Items were selected based on their interpretability with the scale descriptors used previously (Affective, Cognitive, Value), and on their loadings. From the initial solution, 5 items were chosen from factor 1 (loadings >0.7), 3 items were chosen from factor 2 (loadings >0.5), and 3 items were chosen from factor 3 (loadings >0.6). Using the principle axis factoring extraction method with direct oblimin rotation (KMO = 0.847), 3 factors were identified which accounted for 65.58% of the total variance. The pattern and structure matrices are shown in Table 3. Factor correlations were 0.00 between factors 1 and 2, −0.63 between factors 1 and 3, and 0.153 between factors 2 and 3. This analysis suggests that the ASCI can be presented as an 11 item inventory with three sub-scales, however, a confirmatory factor analysis is required to endorse this suggestion.

Individual items within each factor may lack an obvious interpretation with respect to that factor, and may appear irrelevant when isolated. However, values for Cronbach's alpha for each identified factor were maximised when the composition of the three factors was as reported. Also, it is likely that the factors identified with the current exploratory factor analysis have some overlap, and this is supported by the correlation between factor 1 and 3 (−0.607). The multidimensional structure of attitude is consistent with inter-connected sub-scales, and the factors identified in the current study have been interpreted within the tripartite structure proposed by Rosenberg and Hovland (1960). Our interpretation of the third factor as representing 'value' is based on the descriptors of the items by Bauer (2008), and the exploration of components of attitude by Visser *et al.* (2006). In the current study, we chose to use the original ASCI and not the shortened ASCIv2. We speculate that using the ASCI in its complete original form may allow ''value'' to be elicited whereas the shortened ASCIv2 survey may not. Upon commencement of studies at USP, students choose to enrol in specific science discipline based courses, meaning they have already decided on pursuing a career in chemistry. This may be the reason why a ''positive attitude'' towards ''Value'' has been identified in this cohort of students. In previous studies the cohort of students investigated had not necessarily made discipline specific career decisions at the time the survey was conducted, which may be why this descriptor was not previously identified. Another key factor here is that the complete survey originally proposed by

Bauer (2008) was used, whereas if the shortened version (ASCIv2) is used then this factor would not be able to be identified.

All participants were studying either foundation science or first year chemistry, in the English language. However, the culture-inclusive curriculum and diversity of the region pre-dispose the student cohort to be multi-lingual (Chandra, 2012). Local Indigenous Fijian dialects, Polynesian and Melanesian languages (for example, Samoan, Tongan, Pidgin English, Kiribati) and languages prevalent on the Indian sub-continent (for example, Hindi, Tamil/Telegu, Gujarati, and Punjabi) would be the common first languages for the students in the cohort surveyed in this research project. Thus, it is possible that participants in this study assigned different meaning to some of the terms used in the ASCI, and this may restrict the use of a semantic differential instrument in such a multi-lingual population. Also, the internal structure with three factors identified in our study was different to the two factor solution identified by Xu and Lewis (2011), and this may reflect the interpretation of individual terms used on the ASCI by the Fijian cohort. To our knowledge, different language versions of the ASCI have not been subjected to any analyses.

The decision to pool the responses from the Foundation year and the First year undergraduate students was initially based on the similarity of the responses to individual items within the inventory. Evidence to support this decision comes from the lack of differences recorded when individual item scores were compared between the two student groups, and further post-hoc comparisons between the mean scores for each identified factor. No differences were recorded between the two student groups. Data collected from the original ASCI and the shortened ASCIv2 were pooled for analysis by Brandriet *et al.* (2011), and data collected from two separate classes (n = 61 and n = 53) were pooled by Xu *et al.* (2012). The administrators of ASCI in the current study were required to give the same instruction to each student group, and we achieved a >75% return rate for completed questionnaires. Thus we are confident that the decision to pool the data from the two student populations was correct and increased our level of confidence with the results of the EFA. Also in the current study, both on-line and hard copy formats were used to administer ASCI. The simplicity of the semantic differential and Likert scale format of the ASCI lends itself to both on-line and paper formats, and we are confident that using both types of delivery did not alter the responses. Changing the physical form of the instrument may introduce noise, however, when ASCI and another questionnaire were co-administered (Bauer 2008), no order effects were reported suggesting that the instrument was robust.

In summary, the ASCI tool was shown to be effective in quantifying attitude to chemistry in this cohort. This study uniquely showed a similar attitude to chemistry in both foundation and first year students. It is the first application of the original ASCI in a cohort of foundation students, and the first application of the ASCI to a demographically unique cohort of BSc chemistry students in the Pacific Island region. Our exploratory factor analysis has described an internal data structure with three sub-scales. Two of these sub-scales were consistent with the established constructs of attitude, namely affective and cognitive; however, a third sub-scale possibly reflected a student's choice of chemistry as a career path. We suggest that the ASCI may be a suitable tool to quantify attitude at regular intervals throughout a degree pathway, thus complementing the routine assessment of content specific knowledge. We also suggest that it may be a suitable instrument to quantify the impact of novel approaches to teach chemistry and further engage students in the scholarship of chemistry.

References

Abdullah M., Mohamed N. and Ismail Z. H., (2009), The effect of an individualized laboratory approach through micro-scale chemistry experimentation on students' understanding of chemistry concepts, motivation, and attitudes, *Chem. Educ. Res. Pract.*, **10**, 53–61.

Adams W. K. and Wieman C. E., (2010), Development and validation of instruments to measure learning of expert-like thinking, *Int. J. Sci. Educ.*, **33**, 1289–1312.

Ajzen I. and Fishbein M., (1980), *Understanding Attitudes and Predicting Social Behavior*, Englewood-Cliffs, NJ: Prentice-Hall.

Akl E. A., Sackett K. M., Erdley W. S., Mustafa R. A., Fiander M., Gabriel C. and Schünemann H., (2013), Educational games for health professionals, *Cochrane Database of Systematic Reviews*, (1), CD006411, DOI: 10.1002/14651858.CD006411.pub3.

Bagozzi R. P. and Burnkrant R. E., (1979), Attitude Measurement and Behaviour Change: A Reconsideration of Attitude Organization and Its Relationship to Behaviour, *Adv. Consum. Res.*, **6**, 295–302.

Barbera J., Adams W. K., Wieman C. E. and Perkins K. K., (2008), Modifying and validating the Colorado Learning Attitudes about Science Survey for use in chemistry, *J. Chem. Educ.*, **85**(10), 1435–1439.

Bauer C., (2008), Attitude towards chemistry: a semantic differential instrument for assessing curriculum impacts, *J. Chem. Educ.*, **85**(10), 1440–1445.

Berg C A., (2005), Factors related to observed attitude change toward learning chemistry among university students, *Chem. Educ. Res. Pract.*, **6**(1), 1–18.

Bland J. M. and Altman D. G., (1997), Cronbach's alpha, *Br. Med. J.*, **314**, 572.

Brandriet A. R., Xu X., Bretz S. L. and Lewis J. E., (2011), Diagnosing changes in attitude in first-year college chemistry students with a shortened version of Bauer's semantic differential, *Chem. Educ. Res. Pract.*, **12**, 271–278.

Chandra S., (2012), Conquering the Oceanic Divide: 12 Centers One Link – ICT, International Conference on ICT Culture in Education, New Delhi, p. 25.

Coll R. K., Dalgety J. and Salter D., (2002), The development of the chemistry attitudes and experiences questionnaire (CAEQ), *Chem. Educ. Res. Pract. Eur.*, **3**(1), 19–32.

Cortina J. M., (1993), What Is Coefficient Alpha? An Examination of Theory and Applications, *J. Appl. Psychol.*, **78**(1), 98–104.

Cronbach L. J., (1951), Coefficient alpha and the internal structure of tests, *Psychometrika*, **16**, 297–333.

Fazio R. and Williams C., (1986), Attitude accessibility as a moderator of attitude-perception and attitude-behavior relation: an investigation of the 1984 presidential election, *J. Pers. Soc. Psychol.*, **51**, 505–514.

Freedman M. P., (1997), Relationships among laboratory instruction, attitude toward science, and achievement in science knowledge, *J. Res. Sci. Teach.*, **34**(4), 343–357.

Grove N. P. and Bretz S. L., (2007), CHEMX: Assessing Students' Cognitive Expectations in Learning Chemistry, *J. Chem. Educ.*, **84**(9), 1416–1424.

Heredia K. and Lewis J. E., (2012), A Psychometric Evaluation of The Colorado Learning Attitudes about Science Survey (CLASS) for Use in Chemistry, *J. Chem. Educ.*, **89**(4), 436–441.

Jokhan A. and Sharma B., (2010), Teaching Science at a Distance, in Kennepohl D. and Shaw L., (ed.), *Accessible Elements: Teaching Science Online and at a Distance*, Canada: Athabasca University Press, pp. 235–246.

Koponen J., Pyorala E. and Isotalus P., (2012), Comparing three experiential learning methods and their effect on medical students' attitudes to learning communication skills, *Med. Teach.*, **34**, e198–e207.

Osborne J., Simon S. and Collins S., (2003), Attitudes towards science: a review of the literature and its implications, *Int. J. Sci. Educ.*, **25**(9), 1049–1079.

Panter A. T., Swyger K. A., Dahlstrom W. G. and Tanaka J. S., (1997), Factor analytic approaches to personality item-level data, *J. Pers. Assess.*, **68**, 561–589.

Rosenberg M. J. and Hovland C. I., (1960), Cognitive, Affective and Behavioural Components of Attitudes, in Rosenberg M. J. and Hovland C. I., (ed.), *Attitude Organization and Change: An Analysis of Consistency Among Attitude Components*, New Haven: Yale University Press.

Sharma B., Jokhan A. and Prasad A., (2011), Online Learning Environment in Mathematics *via* a Pedagogical Progression Model of Moodle, *Proceedings of Global Learn Asia Pacific 2011*, Melbourne: AACE, pp. 2241–2251.

Shaw J., (2012), Using small group debates to actively engage students in an introductory microbiology course, *J. Microbiol. Biol. Educ.*, **13**(2), 155–160.

Sijtsma K., (2009), On the use, the misuse, and the very limited usefulness of Cronbach's alpha, *Psychometrika*, **74**(1), 107–120.

Tesser A. and Shaffer D. R., (1990), Attitudes and Attitude Change, *Annu. Rev. Psychol.*, **41**, 479–523.

Visser P. S., Bizer G. Y. and Krosnick J. A., (2006), Exploring the Latent Structure of Strength-Related Attitude Attributes, *Adv. Exp. Soc. Psychol.*, **38**, 1–67.

Xu X. and Lewis J., (2011), Refinement of a chemistry attitude measure for college students, *J. Chem. Educ.*, **88**, 561–568.

Xu X., Southam D. and Lewis J., (2012), Attitude toward the subject of chemistry in Australia: an ALIUS and POGIL collaboration to promote cross-national comparisons, *Aust. J. Educ. Chem.*, **72**, 32–36.