International Journal of Innovation and Research in Educational Sciences
Volume 5, Issue 2, ISSN (Online) : 2349–5219

# Attitude to the Subject of Chemistry in Nursing and Health Science Undergraduate Students

**S. J. Brown and M. Naiker**
Auckland University of Technology, Akoranga Drive, Auckland, NZ
Australian Catholic University, Nudgee Road, Banyo, Queensland, AU

*Abstract* – **Nurses require an understanding of biological sciences but may fear chemistry. We quantified attitude to chemistry in both nursing students, and health science students. Attitude toward the Subject of Chemistry Inventory (ASCI) was completed by 114 first year nursing students, and 88 health science students, enrolled in a regional university in Australia. Exploratory factor analysis identified items in the inventory which aligned to a common theme, and Cronbach's alpha) determined the internal consistency of items which aligned with the identified theme. Two themes identified were named "Cognitive" and "Affective", both of which are components of attitude. Cognitive refers to thoughts evoked by chemistry, and affective refers to emotional responses to chemistry. Quantifying attitude to chemistry may be used to measure the effects of both teaching chemistry to undergraduate nurses, and to assess the impact of novel strategies to engage undergraduate nurses in the subject of chemistry.**

*Keywords* – **First Year Undergraduates, Chemistry Education Research, Testing and Assessment.**

## I. Introduction

Many health science undergraduate degree courses share both a common scientific language and body of knowledge, yet some aspects of bioscience, particularly chemistry, are perceived as difficult by many students [1]. The extent of knowledge and understanding of chemistry by those qualified in the health sciences, including nurses, varies considerably, as do their practices and responsibilities. However, as nurses continue to develop and expand their roles, a commensurate increase in their need to understand the principles of chemistry may underpin many future practices. Student entry into undergraduate nursing programmes is often by diverse and non-traditional pathways [2], and although the pre-university entry study of chemistry has been shown to be a strong indicator of success in a nursing undergraduate programme [3], it is not required for all nursing degrees. A limited familiarity with chemistry was reported as a cause for concern during the expansion of the independent prescribing of medicines by non-medically qualified practitioners [4], and while physiology was perceived as essential for a comprehensive undergraduate nurse education [5], knowledge of the chemistry which underpinned undergraduate physiology was limited. Others [6, 7] have stated that knowledge of chemistry was perceived by health professionals as important, essential for questioning medical decisions and ensuring patient safety, but was limited in its undergraduate delivery. Thus, while physiology is accepted as an essential requirement of undergraduate health science courses [6] the need to understand the principles of chemistry which underpin physiological concepts may often be overlooked.

The promotion of favourable attitudes towards chemistry has long been a component of the education process, however the concept of an attitude towards the subject of chemistry is somewhat nebulous, often poorly articulated and not well understood [8]. Academic curricula may encourage gains in both content specific knowledge and promote a positive attitude toward the subject. Students are required to develop an understanding of specific content – this is supported by an extensive body of teaching and learning pedagogy, however, methodologies to develop a positive attitude to a subject (and quantify attitude to the subject), are less extensive. A positive attitude to chemistry in undergraduate nurses may facilitate a deeper understanding of the biological chemistry which underpins physiology. It may also increase the confidence of undergraduate nurses when dealing with chemical phenomena, for example, acid-base balance disturbances, in a clinical situation.

Attitude is a multidimensional construct. It can be considered as tendency to respond to a certain stimulus, where the response has cognitive, affective, and behavioural elements. We suggest that an appropriate instrument to quantify attitude to a subject during an undergraduate course [9] may prove valuable, as this would complement the regular assessment of content specific knowledge. To quantify attitude toward the subject of chemistry in an undergraduate curriculum and assess the impact of teaching on attitude as students' progress through their degree, an appropriate and valid instrument is required. Academic curricula continually evolve to satisfy the demands of the workplace, and therefore appropriate assessment tools which measure both achievement and attitude may become increasingly important. Therefore, our aim was to apply a questionnaire purporting to quantify attitude to the subject of chemistry, to a cohort of undergraduate nursing student and health science students.

## II. Methods

With ethics committee approval, the Attitudes toward the Subject of Chemistry Inventory (ASCI; see figure 1) was given to first year undergraduate nursing students undertaking a compulsory course in physiology, and undergraduate health science students undertaking a compulsory course in introductory chemistry. Students were recruited into the study during the 6$^{th}$ week of their first semester of their first year of university study. The ASCI was distributed to students by a colleague not connected to either the courses or the research, and students were given approximately 15 min to complete the questionnaire.

International Journal of Innovation and Research in Educational Sciences
Volume 5, Issue 2, ISSN (Online) : 2349–5219

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. Attitude to the Subject of Chemistry Inventory (ASCI). A 20 - item semantic differential instrument used to quantify attitude in undergraduate students studying introductory chemistry. For analysis, scores were reversed for items 1, 3, 6-9, 11-16, 19, and 20, using: -1*(n – 8).

Questionnaires were completed by 114 nursing students. This was distributed to students in a tutorial class setting (maximum number in each tutorial was 25 students), during a normal teaching period. All nursing students were undertaking a 12 week first year university course in introductory human anatomy and physiology, with a weekly 3hour lecture and a weekly 1hour tutorial. Within this course several topics with 'chemistry content' were introduced, examples of which are: electrolyte and acid-base balance, nutrition and metabolism, and endocrinology.

Questionnaires were also completed by 88 health science students enrolled in Biomedical Science and Food Science degrees. This was distributed to students in a 2hour fortnightly tutorial, during a normal teaching period. All health science students were undertaking a compulsory first year 12week introduction to chemistry course with a 2hour weekly lecture allocation, a fortnightly tutorial and a fortnightly practical class. Topics in this course covered both organic chemistry and inorganic chemistry.

For both the nursing students and the health science students, exploratory factor analysis was carried out using IBM SPSS Statistics 19. Factors were extracted by the principal axis factoring method with varimax rotation. Visual inspection of the scree plot was used to identify the number of factors required for a solution – for both groups a two-factor solution was strongly suggested by visual inspection of the scree plots.

Internal consistencies were calculated by Cronbach's alpha for each subscale – this statistic indicates the degree to which item scores in a subscale correlate with each other and the total score. Cronbach's alpha values close to 1 (the maximum possible) suggest that the items in the subscale are each measuring the same construct.

## III. Results

Mean (standard deviation) responses to each ASCI item are shown in table 1. Possible scores for each item are from 1 to 7 inclusive, and a score of 4 for an item indicates no preference for either of the opposing terms.

Table I. Mean (SD) responses to the Attitudes to the Subject of Chemistry Inventory (ASCI) in nursing undergraduates and health science undergraduates. Each question was scored from 1 – 7. For the semantic differential applicable to each item, see figure 1.

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Nursing (n=114) | 5.9 (1.3) | 5.1 (1.3) | 4.4 (1.8) | 3.1 (2.1) | 3.0 (2.0) | 3.8 (1.5) | 5.0 (1.7) | 3.3 (1.7) | 4.4 (1.5) | 2.3 (1.7) |
| Health Science (n=88) | 5.3 (1.6) | 5.8 (1.2) | 3.6 (1.3) | 2.9 (1.7) | 3.5 (1.6) | 3.1 (1.4) | 3.8 (1.7) | 3.8 (1.4) | 3.6 (1.3) | 2.3 (1.6) |

| | Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 | Q20 |
|---|---|---|---|---|---|---|---|---|---|---|
| Nursing (n=114) | 4.7 (1.5) | 3.5 (1.9) | 4.0 (1.5) | 4.7 (1.6) | 3.1 (1.5) | 2.3 (1.6) | 3.5 (1.7) | 3.7 (1.6) | 2.8 (1.4) | 3.7 (1.5) |
| Health Science (n=88) | 3.8 (1.2) | 2.8 (1.6) | 4.4 (1.2) | 4.1 (1.4) | 2.6 (1.5) | 2.6 (1.4) | 4.4 (1.6) | 3.6 (1.5) | 3.3 (1.5) | 4.0 (1.5) |

For the undergraduate nursing students, the Kaiser-Meyer-Olkin (a measure of sampling adequacy) was >0.75, indicating that there were sufficient responses to justify the exploratory factor analysis approach. Also, for the undergraduate health science students, the KMO was >0.75. For the undergraduate nursing students, our exploratory factor analysis indicated that two principle components explained much of the variance within the data. Initial eigenvalues for components 1 and 2 were 6.945 and 3.053 respectively – these cumulatively explained 50% of the total variance. We also report a similar finding with the undergraduate health science students, where our exploratory factor analysis also indicated that two principle components explained much of the total variance.

International Journal of Innovation and Research in Educational Sciences
Volume 5, Issue 2, ISSN (Online) : 2349–5219

Table 2. Exploratory Factor Analysis of the Attitude toward the Subject of Chemistry Inventory (ASCI) in undergraduate nursing students (n = 114). Loading profiles and the corresponding ASCI item are shown, and loadings <0.5 are omitted. * denotes a reversed scale in the component.

| ASCI item: | Component: "AFFECTIVE" | ASCI item: | Component: "COGNITIVE" |
|---|---|---|---|
| Q2 worthless – beneficial* | -.613 | Q4 complicated – simple | .727 |
| Q6 good – bad | .708 | Q5 confusing – clear | .771 |
| Q7 satisfying – frustrating | .641 | Q8 scary – fun | .739 |
| Q11 pleasant – unpleasant | .671 | Q10 challenging – not challenging | .730 |
| Q12 interesting – dull | .750 | Q16 work – play | .649 |
| Q15 worthwhile – useless | .704 | Q19 tense – relaxed | .754 |

Initial eigenvalues for components 1 and 2 were 6.370 and 3.496 respectively – these cumulatively explained 49.4% of the total variance. Item – component loading profiles for each of the two-component solutions for undergraduate nursing students and undergraduate health science students are shown in tables 2 and 3 respectively (excluding absolute values <0.5). As shown in table 2, for the undergraduate nursing students, six items loaded onto component 1 (which we have named "Affective"), and six items loaded onto component 2 (which we have named "Cognitive"). For the health science students, the same six items loaded onto each component – however, an additional 3 items could be included in the Affective component, and an additional 2 items could be included in the Cognitive component (see table 3).

Table 3. Exploratory Factor Analysis of the Attitude toward the Subject of Chemistry Inventory (ASCI) in undergraduate health science students (n = 88). Factor loading profiles and the corresponding ASCI item are shown, and factor loadings <0.5 are omitted. * denotes a reversed scale in the component.

| ASCI item: | Factor: "AFFECTIVE" | ASCI item: | Factor: "COGNITIVE" |
|---|---|---|---|
| Q2 worthless – beneficial* | -.535 | Q4 complicated – simple | .673 |
| Q6 good – bad | .571 | Q5 confusing – clear | .666 |
| Q7 satisfying – frustrating | .530 | Q8 scary – fun | .559 |
| Q11 pleasant – unpleasant | .536 | Q10 challenging – not challenging | .792 |
| Q12 interesting – dull | .842 | Q16 work – play | .666 |
| Q15 worthwhile – useless | .794 | Q19 tense – relaxed | .658 |
| additional loadings identified for health science students: | | | |
| Q3 exciting – boring | .592 | Q1 easy – hard* | -.629 |
| Q9 comprehensible – incomprehensible | .594 | Q14 comfortable – uncomfortable* | -.619 |
| Q13 disgusting – attractive* | -.550 | | |

For the undergraduate nursing students, Cronbach's alpha values for the two components were 0.87 and 0.66 for Affective and Cognitive, respectively. For the health science students, the values for the two components were 0.85 and 0.78 for Affective and Cognitive, respectively.

## IV. Discussion

Using an exploratory factor analysis approach, our findings have shown that the ASCI can be used to quantify two components of attitude in both undergraduate nursing students and health science students. To our knowledge, this is the first application of the ASCI to undergraduate nursing students, and only the second application of the ASCI to health science students in Australia [10].

The two identified components can be considered as constructs of attitude, where component 1 has been termed "Affective" and component 2 has been termed "Cognitive". This finding shows some consistencies with the analysis of undergraduate chemistry students in the United States using the same instrument [9, 11]. In our study, items in the ASCI which align with the two identified components and which are common to both students' groups are shown in figure 2. This figure proposes a theoretical framework in which the responses to 6 ASCI items are used to quantify how an individual 'feels' about studying chemistry (Affective), and a further 6 items are used to quantify how an individual 'thinks' about studying chemistry (Cognitive).

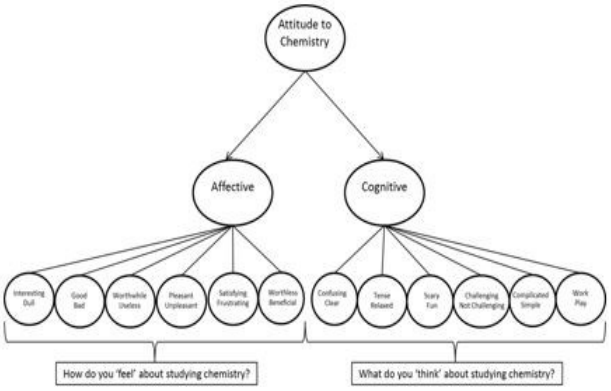


Fig. 2. Theoretical framework aligning the semantic differentials identified in the ASCI with components of attitude, in undergraduate nursing students and health science students.

The ASCI was originally validated in the United States on undergraduates majoring in chemistry [9]. A shorter version of the original 20 item questionnaire was developed by XU and Lewis [11], also in chemistry undergraduates – this version (ASCIv2) contains only eight items in two subscales, "intellectual accessibility" (which aligns to the cognitive component of attitude), and "emotional satisfaction" (which aligns to the affect component of attitude). Using confirmatory factor analysis, Xu et al [10] showed that 4 questionnaire items (Easy – Hard, Complicated – Simple, Confusing – Clear, challenging – Unchallenging) could be included in the 'intellectual accessibility" subgroup. These authors also showed that

four questionnaire items (Uncomfortable – Comfortable, Frustrating – Satisfying, Unpleasant – Pleasant, and Chaotic – Organised) could be included in the "emotional satisfaction" subgroup.

The aim of our exploratory factor analysis was to identify components/sub-scales within the ASCI that explained the co-variation of the measured variables [12]. In the current study it identified two latent variables which we have termed cognitive and affective as these have previously been suggested to be important constructs of attitude [13]. In the current study, the principal axis factoring method (in preference to the maximum likelihood estimation method) was chosen as this method does not require data distribution assumptions. This study also used the observation of the scree plot to conclude that 2 latent variables were present in the data in preference to eigenvalues greater than 1. Given that the total variance available is equal to the number of items analysed, eigenvalues greater than 1 indicate that retained components explain more item variance than individual items. The scree plot is a graphical representation of descending eigenvalues against equally spaced factor numbers. Where the scree plot shows a distinct 'elbow' beyond which the difference in descending eigenvalues becomes small, the number of points preceding this elbow suggests the number of latent factors in the data.

Initially, exploratory factor analysis of the ASCI revealed a four-factor solution [9], where the factors: Intellectual accessibility, Anxiety, Interest and Utility and Emotional Satisfaction were identified. Later, others [11] presented a two-factor solution when using the ASCI in cohorts of undergraduate chemistry students, such that the factors "Intellectual Accessibility" and "Emotional Satisfaction" were identified as the principal components – these two factors were summarised to cognitive and affective, respectively. The cognitive factor relates to both intellectual accessibility and anxiety, and the affective factor relates to emotional satisfaction and interest. Our finding suggests that the ASCI may be used to identify these attitude constructs in both undergraduate nursing and health science students, and that the ASCI may potentially be used to quantify changes in attitude toward the study of chemistry in undergraduates in the health science disciplines.

Many allied health professions require a comprehensive understanding of physiology and pathophysiology – each of these requires some understanding of biological chemistry. Whilst curricula are often designed to deliver content and assess knowledge in these areas, rarely is attitude to these areas assessed. Health science degrees are diverse yet share a common body of knowledge. Understanding aspects of the biological sciences is an important requirement in many health science undergraduate programmes, and this is often reinforced by introductory courses in human biology and/or human physiology [5]. Many aspects of cellular function and physiology require some understanding of chemistry (particularly biochemistry), although its place in the health science curriculum is not assured. In the current study, students studying nursing were required to study two first year courses in introductory chemistry without a requirement to undertake any study of introductory chemistry. The health science students were required to study two first year courses in introductory chemistry, with the option to take additional courses in human biology and human physiology. Neither group of students were required to have any pre - University entry study of chemistry. Although academic performance of both cohorts can be measured using traditional methodologies, there are few valid instruments to quantify attitude in these cohorts. Results from the current study suggest that ASCI represent a suitable instrument to measure constructs of attitude in both nursing and health science undergraduates. It may potentially highlight the need to deliver chemistry education in an appropriate health science context within the undergraduate curriculum or be used to quantify the impact of novel teaching strategies used to develop a positive attitude to chemistry in a health science context.

Knowledge of chemistry may help pre-registration nurses understand the physiology that supports much of their clinical practice; however, the absence of chemistry in undergraduate nursing curricula may compromise this understanding [14]. A lack of bioscience (including biochemistry, physiology, and pharmacology) in pre-registration nursing programmes has previously been reported [5] and this may contribute to the anxieties of newly graduating nurses [15, 16]. These anxieties are not restricted to the newly qualified, as the lack of knowledge of chemistry in both experienced nurses [17, 18] and nurse educators [19, 20] evoked concerns regarding drug actions and pharmacology practices.

## V. Conclusion

Knowledge of chemistry can underpin an understanding of human physiology, and evidence suggests that an apparent fear and anxiety of biosciences, including chemistry, may prevail in undergraduate nursing students. We suggest that an instrument to quantify attitude to chemistry may be a useful tool to gauge the effects of curriculum development in nurse education, and we propose that developing a favourable or positive attitude to chemistry may be congruent with the development of academic competency in chemistry in undergraduate nurses. Exploratory factor analysis of our data on both undergraduate nursing students and health science students indicate that the ASCI, a 20-item questionnaire validated in chemistry majoring students has two subscales. These subscales align with two constructs of attitude, namely "affective" and "cognitive", and are somewhat consistent with a previous report on a refined version of the ASCI. In our further research, we propose to use the ASCI at regular intervals in an undergraduate nursing programme to gauge any changes to key components of their attitude toward chemistry. We also propose to examine the relationship between constructs of attitude and academic performance in health science students.

## Acknowledgment

The Authors are very grateful to The Chemistry Discipline Network for financial assistance (Catalyst Grant 2013).

## REFERENCES

[1] Scalise, K., Claesgens, J., Wilson, M., Stacy, A. (2006) Contrasting the expectations for student understanding of chemistry with levels achieved: a brief case-study of student nurses. *Chemistry Education Research and Practice*, 7(3), 170-184.
[2] Birks, M., Al-Motlaq, M., Mills, J. (2010) Pre-registration nursing degree students in rural Victoria: Characteristics and career aspirations. *Collegian*, 17, 23-29.
[3] Feldt, R.C., Donohue, J.M. (1989) Predicting nursing GPA and national council licensure examination for registered nurses (NCLEX-RN): a thorough analysis. *Psychological Reports*, 64(2), 415-421.
[4] Leathard, H.L. (2001) Understanding medicines: extending pharmacology education for dependent and independent prescribing (Part 2). *Nurse Education Today*, 21, 272-277.
[5] Davis, G.M. (2010) what is provided and what the registered nurse needs – bioscience learning through the pre-registration curriculum. *Nurse Education Today*, 30, 707–712.
[6] Jordan, S. (1994) should nurses be studying bioscience? A discussion paper. *Nurse Education Today*, 14(6), 417-426.
[7] Jordan, S., Reid, K. (1997) The biological sciences in nursing: an empirical paper reporting on the applications of physiology to nursing care. *Journal of Advanced Nursing*, 26, 169-179.
[8] Osborne, J., Simon, S., Collins, S. (2003) Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9), 1049-1079.
[9] Bauer, C.F. (2008). Attitude towards chemistry: A semantic differential instrument for assessing curriculum impacts. *Journal of Chemical Education*, 85(10), 1440-1445.
[10] Xu, X., Southam, D., Lewis, J.E. (2012) Attitude toward the subject of chemistry in Australia: An ALIUS and POGIL collaboration to promote cross-national comparisons. *Australian Journal of Education in Chemistry*, 72, 32-36.
[11] Xu, X., Lewis, J.E. (2011) Refinement of a chemistry attitude measure for college students. *Journal of Chemical Education*, 88, 561-568.
[12] Fabrigar, L.R., Wegener, D.T., MacCallum, R.C., Strahan, E.J. (1999) Evaluating the use of exploratory factor analysis in psychological research. *Psychological methods*, 4, 272-279.
[13] Gorusch, R.L. (1997) Exploratory factor analysis: its role in item analysis. *Journal of Personality Assessment*, 68, 532-560.
[14] Davies, S., Murphy, E., Jordan, S. (2000) Bioscience in the pre-registration nursing curriculum: finding the right teaching strategy. *Nurse Education Today*, 20, 123-135.
[15] Latter, S., Maben, J., Myall, M., Young, A. (2007) Evaluating nurse prescribers' education and continuing professional development for independent prescribing practice: findings from a national survey in England. *Nurse Education Today*, 27, 7, 685-696.
[16] Mooney, M. (2007) Facing registration: the expectation and the unexpected. *Nurse Education Today*, 27, 8, 840-847.
[17] Clancy, J., McVicar, A., Bird, D. (2000) Getting it right? An exploration of issues relating to the biological sciences in nurse education and practice. *Journal of Advanced Nursing*, 32(6), 1522-1532.
[18] Danielson, E., Berntsson, L. (2007) Registered nurses' perceptions of educational preparation for professional work and development in their profession. *Nurse Education Today*, 27, 8, 900-908.
[19] Bradley, E., Blackshaw, C., Nolan, P. (2006) Nurse lecturers' observations on aspects of nurse prescribing training. *Nurse Education Today*, 26, 7, 538-544.
[20] Friedel, J.M., Treagust, D.F. (2005) Learning bioscience in nursing education: perceptions of the intended and the prescribed curriculum. *Learning in Health and Social Care*, 4, 4, 203-216

## AUTHORS' PROFILES

**Dr. Stephen Brown** is a senior lecturer in physiology, with research interests in teaching and quantifying the student experience. Dr. Brown is interested in the transition into higher education for science students, particularly those choosing to study the health disciplines. Dr. Brown has a background in statistical analyses and quantitative research methodologies.

**Dr. Mani Naiker** is a lecturer in science, with extensive teaching experience in higher education in the South Pacific and Australia. Dr Naiker has a keen interest in evaluating teaching, learning and assessment of science education in secondary school and undergraduate tertiary students. Dr Naiker is actively involved in exploring alternative active learning strategies that would inspire, motivate and engage students towards studying science subjects and allow them to enjoy their experiences.