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Evaluating an Instrument to Quantify Attitude to the Subject of Physiology in Undergraduate Health Science Students

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Abstract

The attitude toward a subject contributes to both academic engagement and success at university, yet it is not routinely measured in undergraduate students. Therefore, in two consecutive introductory courses in Human anatomy and physiology (HAP 1, n= 239, and HAP 2, n=329), an instrument to quantify undergraduate students' attitude to the subject of physiology (ASPI) was evaluated using exploratory factor analysis (EFA). In both HAP 1 and HAP 2, EFA indicated two latent components – affective (component 1) and cognitive (component 2). Items comprising each component were consistent for both courses, and alpha coefficients >0.7 indicated good internal consistency. Differences in affective attitude and cognitive attitude between HAP 1 and HAP 2 indicated that students had a more negative attitude to physiology in HAP 2. The ASPI may be a useful instrument to quantify affective and cognitive attitude in undergraduates studying physiology, thus complementing routine assessment of academic performance.

Keywords

attitude, anatomy and physiology, exploratory factor analysis

Introduction

Undergraduates are expected to develop an understanding of subject-specific content, and both the delivery and assessment of this understanding is supported by an extensive body of teaching and learning pedagogy. However, students' attitude to a subject they are expected to study is rarely measured, yet a positive attitude may correlate with higher achievement (Osborne, Simon & Collins 2003; Xu & Lewis 2011; Xu, Southam & Lewis 2012). Also, a positive attitude toward learning new academic content may support ongoing professional education, helping to ensure flexibility within the workplace. Thus, it would seem appropriate to quantify students' attitude to a subject during their undergraduate degree, as this could complement the regular assessment of content-specific knowledge (Berg 2005; Bauer 2008). Developing a positive attitude toward learning, particularly at the start of an undergraduate program of study, may be important for the consistent achievement required at university, and prepare a graduate for the continual professional development expected throughout a health-care career.

Attitude reflects the tendency to respond to a certain stimulus – in this instance, the learning of physiology. The response has both affective and cognitive elements, thus forming a bipartite theoretical model of attitude (Bagozzi & Burnkrant 1979; Rosenberg & Hovland 1960). The "affective" reflects emotional responses through individual preferences to the stimulus, whereas the "cognitive" reflects an individual's knowledge and understanding about the stimulus (Xu, Southam & Lewis 2012). This view of attitude suggests a clear distinction between thoughts and emotions. Thus, attitude to physiology may be identified and quantified within this bipartite structure, but only if appropriate instruments are used that identify these constructs. Somewhat simplistically, attitude in general can be summarised as being positive or negative; it is logical, therefore, to also consider a positive or negative *cognitive* attitude, and a positive or negative *affective* attitude. Therefore, an instrument to quantify attitude and the underlying constructs of attitude may be a useful tool to quantify the effects of novel approaches to teaching physiology.

Teaching pedagogy aimed at developing a positive attitude toward science can be implemented within a curriculum. For example, debate (Shaw 2012), educational games (Akl, Sackett, Erdley, Mustafa, Fiander, Gabriel & Schünemann 2013), role-play (Koponen, Pyorala & Isotalus 2012) and practical experience (Freedman 1997; Abdullah, Mohamed & Ismail 2009) have all been used to develop positive attitudes toward the study of science. However, to quantify the possible influence these pedagogies have on attitudes toward physiology in an undergraduate curriculum, an appropriate and valid instrument that measures attitude is required. The Colorado Learning Attitudes about Science Survey (CLASS; Barbera, Adams, Weiman & Perkins 2008; Heredia & Lewis 2012) has been used to quantify attitude to science in undergraduate students, but not specifically physiology. Also, the Attitudes to the Subject of Chemistry Inventory (ASCI: Bauer 2008; Xu & Lewis 2011; Brown, Sharma, Wakeling, Naiker, Chandra, Gopalan & Bilimoria 2014) has also been used to quantify attitude in an undergraduate curriculum; a modified version of this instrument – the Attitude to the Subject of Physiology Inventory (ASPI) – is evaluated in the current study.

The aim of the current study was to evaluate the ASPI using an exploratory factor analysis approach. We hypothesised that the instrument may contain affective and cognitive sub-scales that could be used to quantify these components of attitude in undergraduate students. Also, we used the ASPI instrument to quantify students' attitudes to physiology in two introductory courses in physiology, where courses were sequential and passing the first was a prerequisite for the second. It was hypothesised that a similar data structure (with two components) would comprise the attitude scores for both courses, and that each component would score similarly in each course.

Methods

This study was carried out at a large, publicly funded higher-education institution approved by its Human Ethics Committee. The university offers a new enrolment opportunity for all prospective students in both January and June; therefore many courses run in both semester periods. A compulsory introductory course in human anatomy and physiology (HAP 1) is taught to all Bachelor of Health Sciences students in their first semester in the program. Passing this course is a requirement for continued progression beyond the first semester and into a second-semester course in human anatomy and physiology (HAP 2).

Figure 1. Attitude to the Subject of Physiology Inventory – A a 20-item semantic differential instrument used to quantify attitude in undergraduate students studying two introductory courses in physiology

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Attitude to the Subject of PHYSIOLOGY Inventory (ASPI).

PLEASE IDENTIFY YOUR RESPONSE TO EACH ITEM BY CIRCLING THE NUMBER IN THE SCALE.

THE SUBJECT OF PHYSIOLOGY 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

Which Programme of study are you following (please circle):

Midwifery, Oral Health, Physiotherapy, Nursing, Psychology
Occupational health, Podiatry, Standard Pathway, Paramedicine, Counselling
Applied Science, Sport and Recreation, Medical Laboratory Science

Which Course are you studying (please circle):

Human Anatomy and Physiology 1 — Human Anatomy and Physiology 2

The health-science programs include nursing, paramedicine, midwifery, physiotherapy, sport and recreation, podiatry, occupational health, oral health and a "standard pathway" (which allows students to enrol but not commit themselves to a named program of study). Students on the Applied Science and Medical Laboratory Science programs are also required to complete and pass both HAP 1 and HAP 2. The programs typically attract students with a diverse range of pre-university educational experiences, including school leavers and those re-entering formal education following a period of either work or unemployment. The gender balance varied considerably between named programs, with approximately 1:1 (female:male) for the sport and recreation program, and approximately 10:1 (female:male) for the nursing programme. The students' demographics were not specifically collected for this study, as access to both student identity and confidential personal details was restricted by the Ethics Committee.

The HAP 1 and HAP 2 courses were delivered as a weekly three-hour lecture (recorded at the time of initial delivery and made available to all students for the remainder of the course), and a weekly two-hour tutorial, over a 13-week period. A mid-semester break of two weeks occurred after week 6 of timetabled lectures, and on return, a seven-week continuous period concluded with an additional two-week examination period. All lecture slides for HAP 1 could be pre-purchased by students, or were made available as downloadable PowerPoint slides (for HAP 2). Additional work sheets were supplied to support learning outcomes in the tutorial sessions. Two one-hour laboratory sessions were part of the HAP 1 course: a bone and joint dissection (bovine) and a heart and lung dissection (lamb). Also, two laboratory sessions were part of the HAP 2 course: the determination of blood-type antigens and the growth of cutaneous microbiota on a culture medium. Students were strongly encouraged to purchase an introductory anatomy and physiology textbook, and although attendance at both lectures and tutorials was not compulsory, it was strongly encouraged. A previously evaluated instrument to measure attitude toward the subject of chemistry (ASCI)(Bauer 2008) was the basis for the instrument used in the current study.

The Attitude to the Subject of Physiology Inventory (ASPI) (Figure 1) was administered to students by university staff not responsible for teaching or assessing the students. Data was collected in weeks 4 and 5 of the course, as this was before any major assessment, but captured all enrolled students (the late-enrolment period extended to the end of week 2). The inventory had 20 equally weighted items, each assessed using a seven-point Likert scale. All students were given appropriate instruction on completing the questionnaire and were given a participant information sheet that described the background and purpose of the research. All data was analysed using appropriate software (IBM SPSS version 22). An exploratory factor analysis was performed on the questionnaire responses using the principle component analysis method with varimax rotation; this method was used on responses for each course separately. The internal validity of any identified components was assessed using the Cronbach's alpha (α) coefficient.

Results

HAP 1: Data were obtained from 239 respondents (>90% return). The Kaiser-Meyer-Olkin measure of sampling adequacy was .869, indicating that the data was suitable for the exploratory factor analysis. A two-factor solution explained 47.8% of the total variance. Initial Eigenvalues of 5.79 and 3.75 were calculated for components 1 and 2, respectively, and visual inspection of the scree plot supported a two-component solution. Eleven items loaded onto component 1, and 8 items loaded onto component 2 (Table 1), with item loadings <.45 excluded. The items that loaded onto components one and two, which have been described as affective and cognitive, respectively, are listed in full in Table 3. The internal consistency of each component was >0.78.

HAP 2: Data was obtained from 329 respondents (> 90% return). The Kaiser-Meyer-Olkin measure of sampling adequacy was .875, indicating that the data was suitable for the exploratory factor analysis. A two-factor solution explained 44.8% of the total variance. Initial Eigenvalues of 5.69 and 3.27 were calculated for components 1 and 2, respectively, and visual inspection of the scree plot further supported a two-component solution. Twelve items loaded onto component 1, and seven items loaded onto component 2 (Table 1). Items with loadings <.45 were excluded. The items that loaded onto components one and two, which have been described as affective and cognitive, respectively, are listed in full in Table 3. The internal consistency of each component was >0.74.

Table 1. Component loadings for ASPI items identified during exploratory factor analysis

HAP 1			**HAP 2**		
Item	**Component**		**Item**	**Component**	
	1	**2**		**1**	**2**
α	**0.786**	**0.788**	α	**0.741**	**0.772**
q6	.812		q12	.751	
q12	.809		q15	.741	
q11	.747		q6	.735	
q15	.739		q11	.699	
q7	.663		q7	.673	
q14	.650		q14	.660	
q13	-.638		q9	.650	
q18	.571		q13	-.596	
q9	.540		q2	-.577	
q2	-.504		q3	.575	
q3	.460		q18	.533	
			q20	-.492	
q19		.767	q19		.689
q5		.745	q10		.681
q4		.737	q4		.672
q10		.718	q5		.668
q1		-.619	q16		.589
q16		.578	q1		-.572
q8		.536	q8		.532
q20		.535			

The extraction method was Principal Component Analysis, and the rotation method was varimax with Kaiser normalisation (rotation converged in three iterations).

Table 2. Mean (standard deviation) component scores for cognitive and affective components of attitude in students in two introductory human anatomy and physiology (HAP) courses

	HAP 1 (n=239)	**HAP 2 (n=329)**
Affective	4.67 (0.68)	4.54 (0.62)*
Cognitive	3.70 (0.45)	3.44 (0.58)*

These values were obtained from the sum of the responses for each scale item composing that scale (maximum score for each item was 7) divided by the number of items in the component.
* denotes a significant difference (P<0.001) using a Student *t*-test.

Comparing HAP 1 with HAP 2: Two components were identified with both HAP 1 and HAP 2, and in both cases these were termed affective (component 1) and cognitive (component 2). Component scores were calculated by summing the scores for the items contributing to each component (allowing for reverse coding on items 1, 3, 6-9, 11-16, 19, and 20 – an approach consistent with the original development of the instrument; Bauer 2008), and dividing this value by the number of items in the component. Thus, mean scores for both cognitive and affective components were calculated for both HAP 1 and HAP 2 respondents (Table 2). Lower scores for both the cognitive and affective components of attitude were recorded for HAP 2 than for HAP 1.

Table 3. ASPI items contributing to the affective component and the cognitive component in two introductory courses in Human anatomy and physiology (HAP 1 and HAP 2).

HAP 1			
	Item	**“positive” term**	**“negative” term**
Component 1: Affective	2	beneficial	worthless
	3	exciting	boring
	6	good	bad
	7	satisfying	frustrating
	9	comprehensible	incomprehensible
	11	pleasant	unpleasant
	12	interesting	dull
	13	disgusting	attractive
	14	comfortable	uncomfortable
	15	worthwhile	useless
	18	safe	dangerous
Component 2: Cognitive	1	easy	hard
	4	complicated	simple
	5	clear	confusing
	8	fun	scary
	10	not challenging	challenging
	16	play	work
	19	relaxed	tense
	20	secure	insecure
HAP 2			
	Item	**“positive” term**	**“negative” term**
Component 1: Affective	2	beneficial	worthless
	3	exciting	boring
	6	good	bad
	7	satisfying	frustrating
	9	comprehensible	incomprehensible
	11	pleasant	unpleasant
	12	interesting	dull
	13	disgusting	attractive
	14	comfortable	uncomfortable
	15	worthwhile	useless
	18	safe	dangerous
	20	secure	insecure
Component 2: Cognitive	1	easy	hard
	4	complicated	simple
	5	clear	confusing
	8	fun	scary
	10	not challenging	challenging
	16	play	work
	19	relaxed	tense

Discussion

In the current study, we evaluated an instrument to quantify attitude to the subject of physiology as taught in two separate courses, both of which were introductory courses for undergraduate students not majoring in physiology. This type of “service course” needs to satisfy the requirements of many degree programs while presenting physiology as a relevant and coherent subject. Measuring attitude in this context is unique, and may be a useful adjunct to the evaluation of the student experience. The last thing educators want to see is students scoring high on tests, but thinking that science is depressing, boring or otherwise unpleasant – science courses that promote both content knowledge and a positive attitude toward science are important for students to stay in advanced science programs and to pursue science-related careers (Xu & Lewis 2011). Our initial evaluation of the ASPI used an exploratory factor analysis method consistent with the evaluation of the original ASCI (Bauer 2008), and the two-component solution is consistent with the theoretical structure of attitude.

A semantic differential scale, which required a respondent to express their attitude toward physiology on a scale indicated by polar adjectives, was selected over the typical alternative (for example, asking respondents indicate the level of agreement with a statement) because we were only interested in the respondents' attitude to physiology, and not their attitudes to studying science or simply being at university. Thus another feature of the semantic differential is trying to focus respondents on a very specific attitude object (Gable 1986) – college students are able to distinguish their feelings and performance among the various disciplines, such as chemistry versus biology versus physics (Bauer 2008). Thus, it was important to focus on the single discipline of physiology; however, this study was the first time this instrument had been used in this context. We proposed to use a confirmatory factor analysis technique to further examine the structure of the data obtained with the ASPI.

The HAP 1 and HAP 2 courses were analysed separately, with very similar results for both exploratory factor analyses. The description of components 1 and 2 as affective and cognitive, respectively, was based on the subjective interpretation of the items that loaded onto each component. This was informed by the original evaluation of the instrument (Bauer 2008), and by the subsequent modification and production of the shortened version of the original instrument (Xu & Lewis 2011). Some items identified in the affective component may appear to be more aligned with a cognitive domain (for example, comprehensible – incomprehensible), and some items identified in the cognitive component may appear to be more aligned with an affective domain (for example, relaxed – tense). The position of an item within a component is endorsed by the exploratory factor analysis; however, its overall contribution to the component is open to interpretation. We used Cronbach's alpha coefficient values to quantify the internal consistency of the items contributing to a component, and all values were >0.7, suggesting reasonably good internal consistency. The bipartite view of attitudes requires cognitive and affective responses that can be separated but are not necessarily independent (Fazio & Williams 1986), suggesting that a single instrument may be inadequate. However, attitude also has characteristics such as importance, certainty and accessibility (Visser, Bizer & Krosnick 2006) – this inter-attitudinal structure may connect different sub-constructs of attitudes to one another, and/or to additional underlying psychological constructs, such as values. Therefore, in the current study, the identification of items that may, on interpretation, appear to align with an alternative component may reflect the underlying complex interrelations consistent within attitude.

Although there was considerable similarity between the items that loaded onto components 1 and 2 for HAP 1 and HAP 2, an exception was item 20. This item loaded onto component 2 for HAP 1 (factor loading 0.535), and onto component 1 for HAP 2 (factor loading -0.492). This item achieved factor-loading scores of -0.34, -0.53, 0.23 and 0.29 in the original evaluation, in which Bauer (2008) identified four factors, whereas a process of scale reconstruction and refinement (Xu & Lewis 2011) removed this item altogether. In this refined version of the attitude questionnaire only eight items remained, with items 1, 4, 5 and 10 loading onto the cognitive scale, and items 7, 14, 11 and 17 onto the affective scale. There are some consistencies with this study's findings of our EFA and the eight-item version of the refined attitude questionnaire, with the exception of item 17 (chaotic – organised): this item did not load (factor loading <0.2) onto either of the two components identified in our EFA. Thus we suggest that this anomaly requires further investigation.

In this study, we have grouped several Likert-type items into a survey scale, and calculated a mean score for the scale items. This practice has been recommended (Lovelace & Brickman 2013; Sullivan & Artino 2013) when attempting to measure less-concrete concepts and a single survey item is unlikely to fully capture the concept being assessed. The exploratory factor analysis technique can provide evidence that the items comprising the scale are sufficiently inter-correlated and that these items, when grouped into a scale, measure the underlying variable. In the current study we used a principle component analysis method of exploratory factor analysis with orthogonal rotation (varimax), consistent with the original evaluation and scale construction of ASCI reported by Bauer (2008). The ASCI was also used in a different study (Brown, Sharma, Wakeling, Naiker, Chandra, Gopalan & Bilimoria 2014), in which a three-factor structure was identified using exploratory factor analysis using the principal axis factoring with the direct oblimin rotation method. The type of rotation used in the current study (varimax) is orthogonal and relies on the assumption that the identified components are independent, whereas the direct oblimin rotation method is oblique and allows components to be correlated with each other. Whether the cognitive and affective components of attitude identified in this study are uncorrelated dimensions is questionable, and should be the subject of further research.

In the current study, a difference between HAP 1 and HAP 2 was identified for both the cognitive and the affective components of attitude, using a parametric Student *t*-test. The choice of a parametric test in preference to a non-parametric test was based on arguments presented elsewhere (Carifio & Perla 2007; Carifio & Perla 2008; Norman 2010; Sullivan & Artino 2013). The differences between HAP 1 and HAP 2 suggested that students on the HAP 2 course had lower scores for both cognitive and affective attitude toward the subject of physiology than those on HAP 1. This may be due to many students perceiving the HAP 2 course as being more difficult and expectations that students understand physiological concepts in more depth; this may negatively affect students who only viewed the course as a hurdle to clear before they embarked on their clinical education. Also, as there was a requirement to pass HAP 1 before undertaking HAP 2, a student's attitude to physiology may have become more negative as they continued to study a topic that was not their chosen program, such as midwifery or paramedicine. University programs that require an understanding of the human body and its physiology, such as nursing, midwifery and paramedicine, often share common introductory courses in anatomy and physiology. These courses may be based around core principles with their origins in biology (Michael, McFarland & Wright 2008; Michael, Modell, McFarland & Cliff 2009); however, there is no firm consensus about the content within an introductory course in physiology (Rathner, Hughes & Schuijers 2013). Students on named degree pathways that focus on health-related topics may fail to engage fully with a generalised human anatomy and physiology course, unless the examples used to demonstrate core principles are more explicit; this may contribute to the lower attitude scores recorded in the HAP 2 course (Freedman 1997). We suggest that the ASPI could be used to regularly measure students' attitudes to physiology, giving the course instructor insight into the effects of their curriculum on their students' attitudes.

Pedagogies that improve the attitudes of some learners, particularly when their learning involves hands-on experiences, has led to recommendations that simulation is well suited to small groups of learners studying health sciences (Levett-Jones, Andersen, Reid-Searl, Guinea, McAllister, Lapkin, Palmer & Niddrie 2015). However, simulations are often conducted in large groups, with few students playing an active role and most observing; this may engage the active student, but the passive observer may feel disconnected and leave with a more negative attitude. A predominantly negative attitude towards puzzles designed to enhance learning in human anatomy and physiology was reported by Stetzik, Deeter, Parker and Yukech (2015), in contrast to others' claims that students find puzzle-based learning fun. A laboratory component is often developed to provide students the opportunity to be engaged in a research-based laboratory and perform analytical techniques in human physiology; these classes can promote both independent thinking and positive attitudes to learning physiology (Rivers 2002). However, in the current study, each course only had two designated laboratory-based practical sessions, in part because the clinical skills these students required to perform their roles as health professionals were taught in other courses. This may have negatively affected the students' attitude to physiology, as they may have perceived the courses to be too theoretical and not "hands on" enough.

A students' attitude can also be negatively affected if there is a disproportionate relation between the degree of perceived effort required to pass an assessment and the credit received for passing it, or if an assessment challenges the learning of the student in unfamiliar ways. Students often emphasise scores achieved in summative assessments, as performance in these assessments may be the decisive factor in a students' progression (Lin, Liang & Tsai 2012); thus it is likely that performance in assessments was likely to affect measures of students' attitudes in this investigation. However, in the current study, data was collected before any assessments to avoid the impact of these events on attitude, and therefore we can only speculate on the effect of assessment on our students' attitude to the subject of physiology.

Conclusion

This is the first study to attempt to measure attitudes to the subject of physiology using the ASPI instrument. The exploratory factor analyses strongly suggested the likelihood of two underlying components in the instrument; these have been described as affective and cognitive, these terms being consistent with the theoretical structure of attitude. We suggest that the ASPI can be used to quantify both affective attitude and cognitive attitudes to the subject of physiology in undergraduate health-science students.

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