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Evaluation of an Instrument to Quantify Student's Attitude to Physiology

S. Brown*, S. White, A. Bowmar and N. Power
SIHS, Auckland University of Technology, Akoranga Drive, Auckland, NZ.
*Corresponding author email id: stephen.brown@aut.ac.nz

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***Abstract*—Attitude toward a subject may contribute 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* — Affective Attitude, Anatomy and Physiology, Cognitive Attitude, Exploratory Factor Analysis.**

I. 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 which they are expected to study is rarely measured, yet a positive attitude may be congruent with higher achievement [1-3]. Also, a positive attitude toward learning new academic content may support on-going professional education, helping to ensure flexibility within the workplace. Thus, it would seem appropriate to quantify student's attitude to a subject during an undergraduate degree as this could complement the regular assessment of content specific knowledge [4, 5]. Developing a positive attitude toward learning, particularly at the start of an undergraduate programme of study, may be important for the consistent achievement required at University, and prepare a graduate for the continual professional development frequently expected throughout a career in health care.

Attitude reflects the tendency to respond to a certain stimulus – in this instance, physiology. The response has both affective and cognitive elements, thus forming a bipartite theoretical model of attitude [6, 7]. The 'affective' reflects emotional responses through individual preferences to the stimulus, whereas the 'cognitive' reflects an individual's knowledge and understanding about the stimulus [3]. 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 which identify these constructs. Somewhat simplistically, attitude can be summarised as being positive or negative, and it is logical therefore, to also consider a positive or negative *cognitive* attitude, and a positive or negative *affective* attitude. An instrument to quantify the underlying constructs of attitude may be a useful tool to quantify the effects of novel approaches to teaching physiology.

Pedagogy aimed at developing a positive attitude toward science can be implemented within a curriculum. For example, debate [8], educational games [9], role play [10], and practical experience [11, 12] have all been used to develop positive attitudes toward the study of science. In order to quantify the possible influence these pedagogies have on attitude toward physiology in an undergraduate curriculum, an appropriate, valid instrument which measures attitude is required. The Colorado Learning Attitudes about Science Survey [13, 14] has been used to quantify attitude to science in undergraduate students, but not specifically physiology. Also, the Attitudes to the Subject of Chemistry Inventory [2, 5, 15], has also been used to quantify attitude in an undergraduate curriculum, and it is a modified version of this instrument – the **A**ttitude to the **S**ubject of **P**hysiology Inventory (ASPI) that 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 which could be used to quantify these components of attitude in undergraduate students. Also, we used the ASPI instrument to quantify students' attitude to physiology in two introductory courses in physiology, where courses were sequential with a pass required in the first as a pre-requisite 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.

II. METHODS

A. Setting

This study was approved by the University's Human Ethics Committee and carried out at a large publicly funded Higher education institution. The University offered a new enrolment opportunity for all prospective students in both January and June, therefore many courses run simultaneously in both semester periods. A compulsory introductory course in Human anatomy and physiology (HAP 1) was taught to all Bachelor of Health Sciences students in their first semester of their first year of study. Passing this course was a requirement for continued

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progression beyond the first semester and into a second introductory course in Human anatomy and physiology (HAP 2) taught in a student's second semester of study.

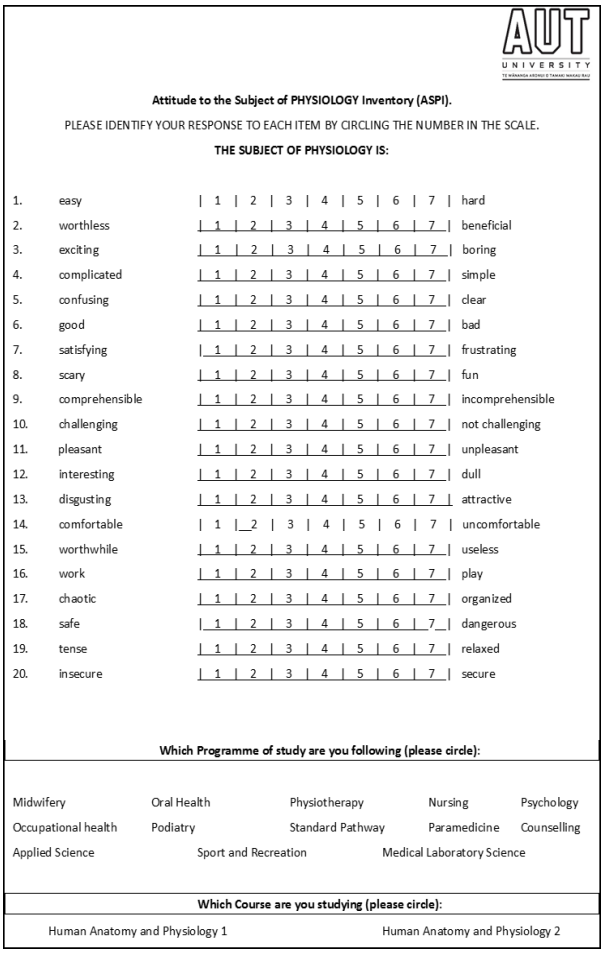
The health science programmes are inclusive of nursing, paramedicine, midwifery, physiotherapy, sport and recreation, podiatry, occupational health, oral health, and those on a 'Standard pathway' (which allows a student to enrol but not commit to a named programme of study). Students on the Applied Science and Medical Laboratory Science programmes are also required to complete and pass both HAP 1 and HAP 2 courses. The programmes typically attracted students with a diverse range of pre-university educational experiences, including both school leavers and those re-entering formal education following a period of either work or unemployment. The gender balance was considerably varied between named programmes, with approximately 1:1 (female: male) for the sport and recreation programme, and approximately 10:1 (female: male) for the nursing programme. Demographics of the students were not specifically collected for this study, as access to both student identity and confidential personal details were 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 2 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 7 week continuous period concluded with an additional two week examinations period. All lecture slides for HAP 1 could be pre-purchased by students, or were made available as downloadable power point slides (for HAP 2). Additional work sheets were supplied and used to support learning outcomes in the tutorial sessions. Two, one hour laboratory sessions were part of the HAP 1 course, these being a bone and joint dissection (bovine), and a heart and lung dissection (lamb). Also, two laboratory sessions were part of the HAP 2 course, these being the determination of blood type antigens and the growth of cutaneous microbiota on culture medium. Students were strongly encouraged to purchase an introductory anatomy and physiology textbook, and although not compulsory, attendance at both lectures and tutorials was strongly encouraged.

B. Data Collection and Analysis

A previously evaluated instrument to measure attitude toward the subject of chemistry (ASCI – Bauer 2008) was used as the basis for the instrument used in the current study.

The Attitude to the Subject of Physiology Inventory (ASPI) – as shown in figure 1, was administered to students by university staff not responsible for teaching or assessing the students. Data were 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 of the semester). The inventory has 20 equally weighted items each assessed using a 7-point Likert scale.



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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

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

All students were given appropriate instruction on completing the questionnaire and were given a participant information sheet which described the background and purpose of the research. All data collected were analysed using appropriate software (IBM SPSS version 22). An exploratory factor analysis was performed on questionnaire responses using the principle component analysis method with varimax rotation - this method was used on responses for each course separately. Internal validity of any identified components was assessed using the Cronbach's alpha (α) coefficient.

III. RESULTS

A. HAP1

Data were obtained from 239 respondents (>90% return). The Kaiser-Meyer-Olkin measure of sampling adequacy was .869 indicating that the data were 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 screen plot supported a two component solution. Eleven items loaded onto component 1, and 8 items loaded onto component 2 – as shown in Table

1, with item loadings <.45 excluded. The items which loaded onto components one and two, which have been described as affective and cognitive, respectively, are listed in full in table three. The internal consistency of each component was >0.78.

Table 1. Component loadings for ASPI items identified during exploratory factor analysis. The extraction method was Principal Component Analysis, and the rotation method was Varimax with Kaiser Normalization (Rotation converged in 3 iterations).

HAP 1			HAP 2		
Item	Component		Item	Component	
	Affective	Cognitive		Affective	Cognitive
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			

B. HAP 2

Data were obtained from 329 respondents (> 90% return). The Kaiser-Meyer-Olkin measure of sampling adequacy was .875 indicating that the data were 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 screen plot further supported a two component solution. Twelve items loaded onto component 1, and 7 items loaded onto component 2. Items with loadings <.45 were excluded.The items which 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.

C. 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 firstly 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, and these are reported in Table 2. Lower scores for both the cognitive and affective components of attitude were recorded for HAP 2 compared to HAP 1.

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. * denotes a significant difference (P<0.001) using a Student *t*-test.

	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)*

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

IV. DISCUSSION

In the current study, we evaluated an instrument to quantify attitude to the subject of physiology, 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 programmes 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 physiology is depressing, boring, or otherwise unpleasant – courses that promote both content knowledge and a positive attitude toward science are important for students to stay in advanced physiology programmes (e.g. Medicine) and to pursue science-related careers [2]. Our initial evaluation of the ASPI used an exploratory factor analysis method consistent with the evaluation of the original instrument [5], 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, indicate the level of agreement with a statement) in order to focus the attention of the respondent on a single attitude object—physiology. In the current study, 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 to a very specific attitude object [16]. It has been shown that college students are able to distinguish their feelings and performance among the various disciplines, such as chemistry versus biology versus physics [5]. Thus, it was important to focus on the single discipline of physiology, however, this is the first time this instrument has been used in this context.

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 which load onto each component. This was informed by the original evaluation of the instrument [5], and by the subsequent modification and production of the shortened version of the original instrument [2]. 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 which can be separated but are not necessarily independent [17], suggesting that a single instrument may be inadequate for quantifying such a multi-dimensional phenomenon.However, attitude also has characteristics such as importance, certainty, and accessibility [18] – this inter-attitudinal structure may connect different sub-constructs of attitudes to one another, and/or to more underlying psychological constructs, for example values. Therefore, in the current study, the identification of items which may, on interpretation, appear to align with an alternative component, may reflect the underlying complex inter-relations consistent within attitude.

Although there was considerable similarity between the items which 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 loaded onto component 1 (factor loading -0.492) for HAP 2. This item achieved factor loading scores of −0.34, −0.53, 0.23, 0.29 in the original evaluation in which Bauer [5] identified 4 factors, whereas a process of scale reconstruction and refinement [2] removed this item altogether. In this refined version of the attitude questionnaire only 8 items remained, with items 1, 4, 5, and 10 loading onto the cognitive scale, and items 7, 14, 11, and 17 loading onto the affective scale (the numbering refers to the listing in the original 20 item scale). In the current study, there are some consistencies with the findings of our EFA and the 8 item version of the refined attitude questionnaire, with the exception of item 17 (chaotic – organized) – this item did not load (factor loading <0.2) onto either of the 2 components identified in our EFA, and 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. Often this practice is recommended [19, 20] when attempting to measure less concrete concepts, and a single survey item is unlikely to be capable of fully capturing 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 [5]. The ASCI was also used in a different study [15] 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 the arguments presented elsewhere [20 – 23] 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 when compared to those on HAP 1. This may be due to the HAP 2 course being perceived by many students as being more difficult and expecting students to understand physiological concepts in more depth – this may negatively impact 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 enrolling into 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 programme, which could have been, for example, midwifery or paramedicne. University programmes which 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 [24, 25], however, there is no firm consensus about the content within an introductory course in physiology [26]. Students on named degree pathways which focus on health related topics may fail to engage fully with a generalized Human anatomy and physiology course, unless the examples used to demonstrate core principles are more explicit, and this may contribute to the lower attitude scores recorded in the HAP 2 course [11]. We suggest that the ASPI could be used to regularly measure students' attitude to physiology, and therefore a course instructor may gain insight into the effects of their curriculum on their students' attitude.

Pedagogies which improve the attitude of some learners, particularly when it equates to hands-on experiences, has led to recommendations that simulation is well suited to small groups of learners studying physiology [27]. 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 has been reported [28], in contrast to the claims of others that implement puzzle-based learning, and describe it as being fun and possessing an entertainment factor. 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 [29]. However, in the current study, each course only had two designated laboratory practical sessions, in part because the clinical skills required by these students to perform their roles as health professionals were taught in other courses. This may have negatively impacted the students' attitude to physiology as they may have perceived the courses to be too theoretical and too little "hands-on".

A students' attitude can also be negatively impacted 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. Scores achieved in summative assessments are often emphasized by students as performance in these assessments may be the decisive factor of a students' progression [30] - thus it is likely that performance in assessments was likely to impact on measures of a student's attitude in this investigation. However, in the current study, data were 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 student's attitude to the subject of physiology.

V. Conclusion

In conclusion, this is the first study to attempt to measure attitude to the subject of physiology using the ASPI instrument. The exploratory factor analyses strongly suggested the likelihood of two underlying components in the instrument, and 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 attitude to the subject of physiology in undergraduate health science students.

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AUTHOR'S PROFILE

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.

Sue White is a senior lecturer in anatomy and physiology, and was awarded a national Tertiary Teaching Award in 2013. Sue is passionate about teaching and learning, with experiences of teaching within the allied health disciplines.

Alex Bowmar is a research officer in the School of Inter professional Health Studies, with a background and interest in study design, ethics, and data collection.

Nicola Power is a senior lecturer in anatomy and physiology with extensive course and program administration experience. Nicola's research interests are in learning and teaching, with a focus on haptic communication.