Engaging Large and Diverse Cohorts of Bioscience Students in Lectures using Kinaesthetic Active Learning

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Abstract

The popularity of flipped teaching, where interactive class-time is combined with online material, is increasing in biomedical education. The challenge for lecturers, particularly with the massification of higher education, is to deliver interaction which is highly motivational and engaging. The aim of this case study was to measure the satisfaction of large and diverse bioscience cohorts with lecturing which used kinaesthetic participation in musculoskeletal lectures. The participation included using the bodies of the lecturer and the students, *en masse* synchronous demonstrations, kinaesthetic mnemonics, student games and anatomical models. Demographic data showed that a high percentage of the students were disadvantaged (e.g., poor-performing, non-English home language, first in family to attend university, low socio-economic status). Students keenly engaged in the activities. The percentages of students who agreed or strongly agreed that communication was effective, that the environment was easy to learn from and that they were satisfied with the teaching were 97.9%, 98.4% and 99.2%, respectively (n=384). Of the 67.2% of students who volunteered comments, 98.1% gave positive responses, with 45.1% of these specifically mentioning the word ‘interactive’ or its synonyms. These findings offer an example of interactive lecturing that could be used in a flipped classroom, particularly for large and diverse cohorts.

Introduction

The anatomy and physiology of the musculoskeletal system is taught to students in a variety of disciplines including Medicine, Health Science and Nursing. Students commonly experience difficulty learning the content of bioscience and appreciating its relevance to their professional careers. The reasons for this are several, including the voluminous content which is, in the main, conveyed in large, didactic lectures (Smales, 2010).

Several alternative modes of delivery have been suggested to the large didactic lecture. Replacing a lecture-based Science course with peer instruction has been shown to improve student retention (Watkins & Mazur, 2013). The flipped classroom, developed for secondary schools (Bergmann & Sams, 2012), is gaining attention in higher education (HE) - including the biosciences. A study by Pierce and Fox (2012) on pharmacy students found that performance in the final exam improved when lecture podcasts were combined with student discussions about patients with end-stage renal disease. However, they found that only 62% of students expressed a desire for more instructors to use a flipped classroom mode. Other studies have also shown that incorporating active learning into science lectures is not always appreciated or preferred (Al-Modhefer & Roe, 2009; Welsh, 2012). Such results suggest that, while active or flipped classroom modes may improve learning, they may not engage all students. Thus, the challenge for academics, especially in subjects with large student numbers and substantial amounts of content, is to select a mode of delivery which is effective, improves understanding and engages students.

Meta-cognitive science suggests that part of the challenge in selecting a mode of delivery for a large number of students is that they have varied learning styles (visual, auditory, reading, kinaesthetic: VARK). Meehan-Andrews (2009) found that the majority of Nursing students preferred to receive information using a kinaesthetic mode and that students considered practical classes to be more useful than lectures. The literature is extensive on active learning as an effective instructional method (Bonwell & Eison, 1991), especially for students with a limited science background (Ernst & Colthorpe, 2007). In Medicine and Science, active lecturing includes demonstrations (Breckler & Yu, 2011; O'Dowd & Aguilar-Roca, 2009), role play (Ross, Tronson & Ritchie, 2005 & 2008; Higgins-Opitz & Tufts, 2010), problem-based learning (Gurpinar, Alimoglu, Mamakli & Aktekin, 2010), question and answer sessions (Gulpinar & Yegen, 2005; Kumar, 2003), small group discussions (Greenop, 2007), personal response systems/clickers (Porter & Tousman, 2010; FitzPatrick, Finn & Campisi, 2011; Deslauriers, Schelew & Wieman, 2011) and mobile devices (Robb & Shellenbarger, 2012). Many of these interactive learning techniques, which are interspersed between longer periods of didactic lecturing, have only brief periods of student participation and do not necessarily use kinaesthetic modes.

The aim of this case study was to measure student satisfaction with lecturing which used kinaesthetic participation in large and diverse Nursing bioscience lectures on musculoskeletal anatomy and physiology. This participation included using the bodies of the lecturer and the students, *en masse* synchronous demonstrations, kinaesthetic mnemonics, student games and anatomical models, including a skeleton named *Napoleon Bone-apart*. Short periods of didactic lecturing were interspersed with longer periods of demonstrations and student participation.

Methods

Students in this study were enrolled in first year nursing at Victoria University (VU). VU is a third tier institution with a high percentage of students who are disadvantaged. There are several characteristics which define students as disadvantaged, many which are related to previous school experiences and socio-economic grouping. Often, they have one or more of the following characteristics: mature aged, under-achieving, disabled, first in the family to attend university and low socio-economic-status (SES). They may be from culturally diverse backgrounds, refugees, English as a Second Language (ESL), or working part or full-time. VU has a higher percentage of low SES enrolments than any other Victorian university (HEPPP, 2011).

Lectures on the musculoskeletal system were given to three cohorts of nursing students whose demographic profiles were obtained from institutional records. Although the mean student score (50.8 ± 0.8%) for the musculoskeletal multiple choice questions (MCQ) was low, the marks were within the range for the other topic areas (43.9 ± 0.8% to 67.9 ± 0.9%) on the final exam. Using the cognitive level criteria of Anderson and Krathwohl (2001), an independent sessional academic categorised the MCQ as level 1 (remember, understand), level 2 (apply, analyse) or level 3 (evaluate, create). The distribution of each level differed between the musculoskeletal system and the other topics (level 1: 38% vs 71%, level 2: 52%

vs 27%, level 3:10% vs 2%). These differences suggest a higher degree of difficulty for the questions on the musculoskeletal system.

In detail, the content of the four musculoskeletal lectures included functions of bone; bone growth and remodelling; axial and appendicular skeletons; bony markings; types of joint; components of the six types of synovial joint, including their articular surfaces and movements; cardiac, smooth and skeletal muscle; excitation-contraction coupling and the sliding filament model; origins, insertions and contraction of skeletal muscles; and comparison of the hip and shoulder joints, in terms of their stability and degree of movement. These facts/concepts were conveyed during the lecture via the students' active involvement.

Active strategies included the lecturer encouraging students, *en masse,* to stand, touch and name each of the bones on their body and call out the correct anatomical names of bony markings (e.g., head of femur). This activity was repeated several times in a process which became progressively faster. Kinaesthetic mnemonics were used to teach the types of synovial joint. For example, students covered their fist with their concavely-shaped other hand in order to simulate a ball and socket joint. Students also simulated hip and shoulder movements while calling out the name of the movement (e.g., flexion). All students stood to perform movements for a range of joints. Students also volunteered to play a game, which involved performing concurrent and successive movements (e.g., protruding the jaw while flexing the thigh and circumducting the arm) as spontaneously and enthusiastically requested by the audience. Difficult concepts were conveyed by demonstrations where the whole class performed actions, including a 'Mexican wave' to illustrate nerve impulses. Major concepts of muscle contraction were also demonstrated by student volunteers. Using a piece of string to simulate a skeletal muscle, and responding to audience instructions, they actively demonstrated the more complex roles of muscles which cross two joints and/or are able to perform different functions by reversing their origin and insertion.

To determine the level of student satisfaction with these active learning methods, student responses were measured using a formal teaching evaluation tool which consisted of eight questions on a five point *Likert* scale plus an open-ended comment. Sample sizes were based on lecture attendances, which were low (on average 50%) but similar to other studies (Davis, Hodgson & Macaulay, 2012). All open-ended comments were categorised as either negative or positive by an independent sessional academic. The negative comments were primarily about the size of the diagrams in the lecture synopses. The positive comments were further categorised as either general (exemplified by words such as 'awesome', 'fun', 'humorous', 'engaging', and 'motivating') or interactive (exemplified by words such as 'interactive', 'participation', 'hands-on', 'standing up', 'class involvement', 'calling out answers', and 'being physical'). Data were analysed using Excel's Pivot Tables and one way ANOVA, with significance set at $p < 0.05$. This case study received approval from the VU Human Research Ethics Committee (HRE13-004).

Results

Student Profile

The mean tertiary entrance score of the three cohorts was 53.2 ± 14.2 (n=405). This indicates a high proportion of poor-performing students (Table 1). Overall, 63% (n=882) were born outside Australia or had one parent born outside the country, with 40.8% of students using a non-English language at home. A high proportion of the students were first in the family to attend university with 70.4% of mothers (n=697) and 71.8% of fathers (n=678) never having attended university. Overall, 26.4% of students were low SES (n=819).

Interactive Lecturing

In the lectures, students keenly engaged in the kinaesthetic activities. For example, on request, students *en masse* used their bodies to demonstrate their understanding of anatomical terms (at least 20, e.g., 'anterior'), bones (at least 35, e.g., 'femur', 'floating rib') and bony markings (at least 25, e.g., 'iliac crest'), while using the correct anatomical language. They used kinaesthetic mnemonics to simulate joints and their movements (e.g., pivot joint – one finger in a C-shape and another finger representing a pin head; radioulnar joint – supination and pronation). In total, the students performed over 60 different movements with accompanying verbal descriptions. Students were keen to volunteer to be in the games and role plays at the front of the lecture theatre. The interactive lectures were often noisy, but a sense of order and purpose was maintained. Analysis of lecture recordings showed that, for each hour, the approximate amount of time spent with didactic lecturing was 20%, with interactive lecturing comprising demonstrations 30%, student 'hands on' 30% and vocal plus 'hands on' 20%.

Table 1: Profile of Year 1 Nursing students at VU.
Number (n) and percentage (%) of students in each cohort, and aggregated. The Australian Tertiary Entrance Score (ATAR: maximum 99.95, median 69.2) is a measure of a student's overall academic achievement on completion of their secondary education, relative to that of the student cohort at the start of their secondary education (Weber, 2014).

		Cohort 1		Cohort 2		Cohort 3		Aggregate	
		n	%	n	%	n	%	n	%
Sex	Female	247	85.8	255	89.2	266	86.4	768	87.1
	Male	41	14.2	31	10.8	42	13.6	114	12.9
Age	17-19	127	44.1	119	41.6	120	39.0	366	41.5
	20-24	98	34.0	82	28.7	96	31.2	276	31.3
	25-29	25	8.7	36	12.6	38	12.3	99	11.2
	30-34	13	4.5	19	6.6	25	8.1	57	6.5
	≥ 35	25	8.7	30	10.5	29	9.4	84	9.5
Tertiary Entrance Score (ATAR)	≤ 39	6	40.0	27	14.9	31	14.8	64	15.8
	40-49	4	26.7	28	15.5	36	17.2	68	16.8
	50-59	3	20.0	38	21.0	68	32.5	109	26.9
	60-69	2	13.3	78	43.1	67	32.1	147	36.3
	≥ 70	0	0.0	10	5.5	7	3.3	17	4.2
Language Spoken at Home	English	163	56.6	159	55.6	200	64.9	522	59.2
	Non-English	125	43.4	127	44.4	108	35.1	360	40.8
Student's Birthplace	Home Country	184	63.9	180	62.9	210	68.2	574	65.1
	Other Country	104	36.1	106	37.1	98	31.8	308	34.9
Mother's Birthplace	Home Country	115	39.9	125	43.7	145	47.1	385	43.7
	Other Country	173	60.1	161	56.3	163	52.9	497	56.3
Father's Birthplace	Home Country	112	38.9	108	37.8	140	45.5	360	40.8
	Other Country	176	61.1	178	62.2	168	54.5	522	59.2
Mother's Educational Level	≤ Year 10 High School	63	33.5	90	36.0	88	34.0	241	34.6
	Year 12 High School	47	25.0	43	17.2	57	22.0	147	21.1
	Technical Education	31	16.5	34	13.6	38	14.7	103	14.8
	≥ Bachelor's Degree	47	25.0	83	33.2	76	29.3	206	29.6
Father's Educational Level	≤ Year 10 High School	64	34.2	80	33.3	95	37.8	239	35.3
	Year 12 High School	42	22.5	37	15.4	55	21.9	134	19.8
	Technical Education	35	18.7	38	15.8	41	16.3	114	16.8
	≥ Bachelor's Degree	46	24.6	85	35.4	60	23.9	191	28.2
Socioeconomic Status	Low	82	29.6	67	26.9	67	22.9	216	26.4
	Medium	144	52.0	152	61.0	179	61.1	475	58.0
	High	51	18.4	30	12.0	47	16.0	128	15.6

Student Evaluations

In aggregate over the three cohorts, the mean scores (5 point *Likert* scale) for *overall satisfaction*, *knew subject matter*, *provided an easy to learn from environment* and *well organised* were 4.9, 4.9, 4.8 and 4.7, respectively (Table 2). The mean for *communicated effectively* was highest in cohort three, with the aggregate mean being 4.9. The scores for *responded well to student needs and questions*, *sought feedback* and *provided feedback* increased from cohort one to cohort three, with their aggregate means being 4.6, 4.7 and 4.4, respectively.

Of the 67.2% of students who volunteered open-ended comments, 98.1% gave positive responses (Table 3). Of the positive comments, 45.1% explicitly referred to the interactive mode of the lectures. Several of these comments suggested that students were able to understand and remember the content because of the interactive nature of the lectures (Table 4).

Table 2: Student responses to questionnaire.

Percentage of students (%), number of responses (n) and mean *Likert* score (1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree).

	Strongly Agree/ Agree %	Neutral %	Strongly Disagree/ Disagree %	n			Mean		
Cohort	1 to 3	1 to 3	1 to 3	1	2	3	1	2	3
Satisfied	99.2	0.8	0.0	140	94	146	4.9	4.9	4.9
Knew subject matter	98.9	1.1	0.0	141	95	144	4.9	4.9	5.0
Easy-to-learn environment	98.4	1.3	0.3	139	93	145	4.8	4.8	4.9
Well organised	96.1	3.1	0.8	140	96	145	4.7	4.7	4.8
Communicated effectively	97.9	1.6	0.5	141	96	147	4.8	4.7	5.0
Responded well	93.7	6.3	0.0	120	83	147	4.5	4.6	4.7
Sought feedback	95.1	4.9	0.0	123	89	134	4.5	4.7	4.8
Provided feedback	82.9	16.3	0.8	79	64	108	4.1	4.4	4.6

Table 3: Percentage of students who volunteered open-ended comments.

Positive comments consisted of both interactive and general statements. Aggregate values were calculated from the combined data of all 3 cohorts.

Cohort	Positive		None	Negative
	Interactive	General		
1	39.0	26.3	32.6	2.1
2	15.6	43.8	38.5	2.1
3	29.9	40.8	29.3	0.0
Aggregate	29.7	36.2	32.8	1.3

Table 4: Selection of student comments.

Positive-Interactive
"Very engaging, well presented, interactive. I feel as though I can leave this lecture and actually remember something."
"Group involvement was a great way for the mass amounts of information to sink in."
"I liked the way everyone stood up and label bones, joints etc it was good that everyone was involved."
"Interacting with students and getting us to physically name the bones was great, it made it easy to understand."
"Involved everybody in the lesson to participate in the learning of the class by actions and repeating names etc. Did not fall asleep in this class, as there was a lot of interaction."
"Very effective, continuously involved us in the lecture, getting us to repeat and use actions which kept student involvement."
"Great audience interaction and made it fun. Loved the hands on approach."
"Found it easier to learn with the interactive lectures."
"The approach to teaching - which may be seen as unconventional - was very effective."
"I am not a good participant in active style learning, but did find this style a very good way to learn."
Positive-General
"Knows subject matter very well, engages the classes attention, I learned easier once she had explained a topic and she is funny."
"Teacher made learning fun."

Discussion

In this study, we found that students responded positively to lectures with kinaesthetic activities. Usually, these kinds of activities are conducted only in bioscience laboratories. However, this study has shown that kinaesthetic activities can translate well into lectures with large numbers of students from highly diverse backgrounds.

To ensure that all learning styles were catered for in lectures, the kinaesthetic activities were supported by graphics for visual learners and the spoken word for auditory learners. All learners were supported by synopsis notes which described the relationship between the kinaesthetic activities and the bioscience concepts. We found that 99.2% of students agreed/strongly agreed that they were satisfied with the teaching. The spontaneous applause which followed *en masse* kinaesthetic activities suggested that students, irrespective of their preferred learning style, were happy to be involved. Many students commented that they learned better from the interactive style of lecturing because they were engaged and focused. They stated explicitly that all bioscience lecturers, if they adopted these modalities, would improve learning outcomes.

Capturing the attention of students promotes meaningful learning. We agree with earlier studies (Ernst & Colthorpe, 2007; Al-Modhefer & Roe, 2009; Mulryan-Kyne, 2010) that highlighted the challenges associated with lecturing to large and diverse cohorts and the role of humour, games and fun activities in enlivening a lecture and promoting deeper learning (Ross *et al*., 2005 & 2008; Baid & Lambert, 2010). Several studies have found that active learning strategies are preferred by students from disadvantaged and minority backgrounds.

Greenop (2007) found that 59% of black students preferred small group work to the traditional lecture. Higgins-Opitz & Tufts (2012) found that active learning strategies in physiology lectures were preferred by non-English speaking students and under-achievers. In our study, there was a high percentage of students who were classified as disadvantaged and who responded enthusiastically to interactive lecturing, particularly kinaesthetic modes.

Active learning in lectures has been viewed positively by students in Medical and Science disciplines. Over 73% of students reported 'patient-doctor' role play to be relevant, entertaining, interesting and informative (Higgins-Opitz & Tufts, 2010). Students responded positively to role plays aimed at explaining photosynthesis (Ross *et al*., 2005) and cellular respiration (Ross *et al*., 2008). When small group discussions, such as question and answer sessions, were introduced into lectures, 60% of students rated the lectures as very good/excellent (Gulpinar & Yegen, 2005), 76% thought the method of teaching was good (Kumar, 2003) and 45% preferred this to traditional didactic lectures (Greenop, 2007). In 2009, via interactive lecture demonstrations, O'Dowd and Aguilar-Roca illustrated concepts in cell biology using everyday objects. They found that 90% of students rated these demonstrations as helpful in understanding the lecture material and that 44% wrote positive comments about the demonstrations. A 'hands on' kinaesthetic lecture activity, where tubes containing water and red beads were used to illustrate oxygen-carrying capacity in blood, resulted in *Likert* scores of 4.0 for engagement (Breckler & Yu, 2011). Students considered that personal response systems helped their learning (FitzPatrick *et al*., 2011), with *Likert* scores ranging from 3.7 to 4.4. Our results confirm these earlier studies and provide evidence that interactive lecturing is preferred by students.

Greenop (2007) compared teaching using didactic lectures with teaching using lectures interspersed with small group discussions. When students were questioned about the negative aspects of the small group work, 31% responded that it diverted them from the content of the lecture; 21% responded that students confused each other; and 19% stated that not all students participated. Higgins-Opitz and Tufts (2010) found that approximately 20% of students made negative comments about student role play in lectures, including that it was a waste of time. Kumar's (2003) study, which involved question and answer sessions in lectures, found that only 10% of students included the words 'interactive' or 'participation' in their open-ended comments. In the O'Dowd and Aguilar-Roca (2009) study, only 9% of students specifically mentioned that demonstrations contributed to the interactive nature of the class. We found that our interactive lecturing strategy resulted in 29.7% of students specifically commenting on the 'interactive' or 'participatory' nature. Furthermore, we note anecdotally that, during our exam, many students surreptitiously used their hands to form the kinaesthetic mnemonics learnt in the musculoskeletal lectures.

Possible reasons that our interactive lecture strategy may have been more acceptable to students than these other techniques include that 50% of the lecture time was spent 'hands on', the class was always engaged with the content, discipline was maintained, learning was not limited by unmotivated students and students were not required to do extra preparation. There were, however, disadvantages for the lecturer which included increased preparation time and difficulties transporting large models. This study has several limitations. It was not designed as an intervention study, thus the findings are limited to being observational and descriptive. There was no investigation of the relationships amongst satisfaction with the teaching strategy, preferred learning style, performance on the examination and student profile. Although we have used our lecturing strategy successfully in most areas of anatomy and physiology, this approach may not be easily transferable to all disciplines.

In conclusion, we have shown that student satisfaction with interactive strategies, including *en masse* synchronous demonstrations and kinaesthetic mnemonics, was very high. The findings offer another example of interactive lecturing that could be used in a flipped classroom mode, particularly with students from diverse backgrounds and in large cohorts.

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