Enriching Biosciences in Undergraduate Nursing Programs: Establishment and Assessment of Online Video Resources

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Abstract

Bioscience courses in health programmes increasingly include students with limited 'on-campus' or face-to-face teaching exposure. These students need resources that are flexible, technologically innovative, easily accessible, engaging, and above all effective for learning. We created and evaluated a bank of short (7-15min) Anatomy & Physiology concept-captured video tutorials (CCVTs), accessible and downloadable through University websites. The CCVTs were linked with formative quiz questions. Utilising a prospective, semi-longitudinal design, we explored the effect of CCVTs on summative student performance across three geographically and socially disparate campuses of the same University in Queensland, Australia. Each semester, approximately 630 first year undergraduate nursing students had access to the CCVTs and quizzes; of these, 1 in 3 engaged with the CCVTs and comparative pre/post quizzes. Quiz results were used to evaluate the impact of CCVTs on concept consolidation. Results demonstrated that five out of ten CCVTs in semester 1 and eight out of ten in semester 2 positively correlated with concept consolidation. The number of CCVTs accessed (engagement) was positively correlated with individual course grades (pass/fail) and overall marks (out of 100). The participating students highly rated the perceived usefulness of the CCVTs as supportive learning resources. We conclude that the establishment of a relatively low-tech, remotely accessed, online learning resource can enrich student experience and support performance in perceivably difficult biosciences courses.

Introduction

Undergraduate nursing students exhibit a very high incidence of deleterious academic stress when compared to other health science students within tertiary education (Stecker, 2004). When compared to other subject offerings within an undergraduate nursing programme, the biosciences have presented nursing students with disproportionate anxieties (Cox & Crane, 2014; Craft, Hudson, Plenderleith, Wirihana, & Gordon, 2013). This phenomenon is not too dissimilar to that found in other allied health cohorts, where comparable levels of anxiety have been described in students enrolled in bioscience gateway courses (Cox & Crane, 2014; Harris, Hannum, & Gupta, 2004). Much of this apprehension is associated with; the difficulty and density of content matter, students' lacking confidence in their abilities, and the speed with which these courses are taught (Andrew, Salamonson, Weaver, Smith, O'Reilly, & Taylor, 2008). This heightened level of anxiety, coupled with the complexities of most bioscience

courses, results in students who are likely to propagate negative attitudes and, in turn, are more inclined to disengage and ultimately accept failure.

Another factor compounding the difficulties associated with the effective delivery of bioscience courses (in health programmes) is the ever-changing profile of university students. Many contemporary students are non-school leavers and have work and/or family responsibilities which prevent them from being classified as 'traditional' on-campus students (Wei, Berkner, He, Lew, Cominole, & Siegel, 2009). It is expected that in the near future, 'non-traditional' students in Australia, similar to those in the United States, will make up over half of all university students. Furthermore, the majority of instructors in higher education will be involved in some form of distance education delivery to these students (Bye, Pushkar, & Conway, 2007). Therefore, innovative and evidence-based bioscience curricula must be maintained by tertiary institutions to avoid disengagement and potentially the cessation of formal tertiary education (Elison-Bowers, Snelson, Casa de Calvo, & Thompson, 2008). This presents a unique opportunity to academics when designing and creating online material for 'traditional' and 'non-traditional' students alike. It must not only supplement and support on-campus and/or distant-education courses, but also provide versatility and accessibility, enhance student engagement and be effective in student learning.

Online learning has demonstrated an exponential growth in its use and effectiveness within health science education (Gresty & Cotton, 2003; Hua & Weiss, 2013; Koch, Andrew, Salamonson, Everett, & Davidson, 2010; McVicar, Andrew, & Kemble, 2014). This could be attributed to a number of factors, including the benefits of convenience, flexibility and ease of accessibility, which have all been rated highly (Kala, Isaramalai, & Pohthong, 2010). However, it must be acknowledged that innovative technologically-driven learning does not necessary mean effective, active, student-centred learning; some evidence suggests that the majority of online learning still focusses on content rather than engagement (Glen, 2005), perhaps to its detriment. Based on the critical fundamentals of constructivism, we proposed the use of concept captured video tutorials (CCVTs) in order to build students' conceptual understanding. Each CCVT session was self-paced and designed to highlight key learning outcomes in order to facilitate students making new connections to things they already know. Furthermore, the CCVTs were designed to reinforce knowledge consolidation by providing continual success criteria feedback through the use of integrated formative quizzes. This approach aligned with common features of constructivism; emphasising the construction of new knowledge built upon previous knowledge and so focuses on deeper student experiences to create self-constructed meaning (Ertmer & Newby, 2013; Kala et al., 2010). Tertiary bioscience courses within health disciplines are transitioning from teacher-centred to more student-centred learning, subsequently constructivism is considered an appropriate learning theory for such transition (Kala et al., 2010). In order for online learning activities – based on constructivism - to be successful, they should contain: practice, knowledge, and context (Brown, Collins, & Duguid, 1989). Ultimately, these criteria must promote motivation (Reinke, 2014), which is considered an essential component for constructivism. The CCVTs have been designed to encompass these components whilst providing an easily accessible and safe learning environment.

Methods

Study context

Data was obtained from first year undergraduate nursing students from three geographically and socially disparate campuses of the same university in Queensland, Australia. Participants

were enrolled in Anatomy and Physiology (A&P; bioscience) courses, across two semesters, in 2015. Both courses were the same across all three campuses in respect to delivery and curriculum. Student demographics, video access data, and end of semester marks, were captured using university online systems, and are presented in Tables 1a & 1b, representing semesters 1 & 2, respectively. This protocol was approved by the University Human ethics research committee (NRS/35/14/HREC).

Concept capture video tutorials (CCVTs)
A bank of online video resources covering ten Anatomy & Physiology concepts (per semester) were created by content and educational experts, and linked with pre and post formative questions (Tables 1a & 1b). Each of these CCVTs was (i) 7-15 minutes in length and (ii) designed to cover an important concept within each topic module throughout the course. Each CCVT was created either using PowerPoint with instructor narration or screen drawing construction with narration (similar to the Khan Academy method); both methods were captured and edited using Camtasia software (TechSmith Corporation, Michigan).

Evaluation of CCVTs
Prior to accessing and viewing the video components of the individual CCVTs, participants were required to complete an online pre-quiz (comprised of ~10 MCQs) on the relevant concept topic to establish their baseline knowledge. Upon completion of the video, participants were immediately redirected to complete a post-quiz (~10 different MCQs) on the same concept topic, to ascertain content consolidation. All pre and post-CCVT quiz results were examined, normalised (percentage) and combined across the three campuses to maximise statistical power. Aggregating student engagement data from the three campuses provided semester 1 data with 85% power to detect mean mark differences of ≥5 marks with a significance level of 0.05. Semester 2 data had 88% power to detect mean mark differences of ≥5 marks with a significance level of 0.05.

The effectiveness of engagement with the CCVTs was established by comparing quiz scores from participants who completed both pre and post quizzes. SPSS statistical software was used for the quantitative analysis. Specifically, a paired sample t-test was utilised to determine CCVTs success in topic consolidation by comparing pre versus post quiz marks. In order to confidently describe the effect of CCVT engagement on overall course result and passing success rate, students' results were grouped and dichotomised according to median CCVT engagement (Semester 1: 1-3 CCVTs, N=84; 4-10 CCVTs, N=96 and for Semester 2: 1-3 CCVTs, N=105; 4-10 CCVTs, N=81). An independent t-test was used to determine whether any significant differences in overall course mark were observable for those who effectively engaged in CCVTs compared to those who did not. While the use of multiple t-tests increases the risks of type 1 errors (Field, 2014), this analysis is robust and was supported by calculation of the odds ratio of passing the course. Odds ratios were determined using a binary logistic regression method. A strict Bonferroni test was utilised for multiple comparisons.

Results

Students from each campus accessed the CCVTs equitably (see Table 1a & 1b). The grades achieved overall on each campus were also similar (Table 1a & 1b).

Concept captured video tutorials (CCVTs) topic consolidation effectiveness
Pre-quiz scores were compiled and compared to post-quiz scores across all three campuses for each CCVT (1-10) for each semester (Table 2a & 2b). It can be seen in semester 1 (Table 2a)

7 out of 10 CCVT-linked pre/post-quizzes were significantly different (CCVT quizzes 1, 3, 5, 6, 7, 9, and 10). Five out of 10 mean CCVT quiz scores improved from pre to post questioning (CCVT quiz 1 (mean diff. 14.9%), 5 (mean diff. 29.2%), 6 (mean diff. 7.6%), 9 (mean diff. 8.2%), and 10 (mean diff. 14.9%).

For semester 2 (Table 2b) 9 out of 10 CCVT linked pre/post-quizzes were significantly different (CCVT quizzes 2, 3, 4, 5, 6, 7, 8, 9, and 10). Eight out of the 10 CCVT quiz scores improved from pre to post questioning (CCVT quiz 3 (mean diff. 9.3%), 4 (mean diff. 10.5%), 5 (mean diff. 12%), 6 (mean diff. 10.6%), 7 (mean diff. 9.4%), 8 (mean diff. 14.1%), 9 (mean diff. 21.7%), and 10 (mean diff. 17.2%).

Table 1a – CCVT Engagement: Anatomy & Physiology 1 – Semester 1, 2015

Factor		**Campus 1**	**Campus 2**	**Campus 3**	**Total**
All individuals [a]		126	236	267	629
Engaged individuals [b]		42 (33.3%)	49 (20.8%)	89 (33.3%)	180 (28.6%)
CCVT engagement [b]	**1/ cell**	32	27	53	112
	2/ membrane transport	17	13	39	69
	3/ joints	17	21	39	77
	4/ skin	18	25	39	82
	5/ action potential	13	21	40	74
	6/ tissues	17	20	35	72
	7/ homeostasis	18	20	40	78
	8/ muscular	14	18	32	64
	9/ cardiovascular	12	17	31	60
	10/ heart anatomy	12	18	30	60
CCVT engagement (grouped) [c]	**0**	84	187	178	449
	1-3	21	22	27	84
	4-10	21	27	48	96
Grade ± SD [d]		63.22 ± 16.38	60.68 ± 14.28	66.14 ± 16.23	63.51 ± 15.95
Outcome [e]	**Fail**	25	49	38	112
	Pass	101	187	229	517

[a] number of individuals enrolled in course
[b] number of individuals that accessed the CCVT and attempted pre and post quizzes
[c] CCVTs dichotomised according to median engagement; between 1-3 CCVTs and 4-10 CCVTs (individuals who were engaged with zero CCVTs were removed)
[d] mean ± standard deviation (out of 100)
[e] outcome determined by pass/fail: fail < 50; pass ≥ 50

CCVT engagement and overall course results

Participants from semester 1 (Table 3a) who did not engage with any CCVTs had an average final mark of 59.77 (out of 100). Participants who engaged with 1-3 CCVTs had a mean final mark of 68.76, a mean increase of approximately 9 marks compared to non-participants. Participants who engaged with 4-10 CCVTs had a mean final mark of 76.41, a mean increase of approximately 16.6 marks compared to non-participants.

Participants from semester 2 (Table 3b) who did not engage with any CCVTs had a mean final mark of 53.09 (out of 100). Participants who engaged with 1-3 CCVTs had a mean final mark of 61.99, on average approximately 9 marks higher than non-participants. Participants who engaged with 4-10 CCVTs had a mean final mark of 69.23, an average approximately 16.1 marks higher than non-participants.

In semester 1 (Table 4a), participants who engaged with 1-3 CCVTs were more than twice as likely to pass the course (OR=2.388 (1.155 – 4.936), $P<0.05$) compared to those who did not engage with any CCVTs. Furthermore, participants who engaged in 4-10 CCVTs were nearly 9 times more likely to obtain a pass grade (OR=8.883 (2.754 – 28.648), $P<0.05$).

In semester 2 (Table 4b), participants who engaged with 1-3 CCVTs were more than twice as likely to pass the subject (OR=2.126 (1.837 – 5.318), $P<0.05$) compared to those who did not engage with any CCVTs. Furthermore, participants who engaged in 4-10 CCVTs were more than 6 times more likely to obtain a pass grade (OR=6.301 (2.965 – 13.392), $P<0.05$).

Table 1b – CCVT Engagement: Anatomy & Physiology 2 – Semester 2, 2015

Factor		**Campus 1**	**Campus 2**	**Campus 3**	**Total**
All individuals [a]		143	252	239	634
Engaged individuals [b]		47 (32.9%)	45 (17.9%)	94 (39.3%)	186 (29.3%)
CCVT engagement [b]	**1/ nervous system**	31	32	69	132
	2/ reflex	20	18	43	81
	3/ digestive	25	27	49	101
	4/ hormones	15	17	40	72
	5/ endocrine	16	11	31	58
	6/ breathing	15	11	20	46
	7/ gas transport	12	11	25	48
	8/ blood pressure	16	19	37	72
	9/ fluids	14	13	32	59
	10/ reproduction	16	16	33	65
CCVT engagement (grouped) [c]	**0**	96	207	145	448
	1-3	26	25	54	105
	4-10	21	20	40	81
Grade ± SD [d]		54.97 ± 18.01	53.36 ± 16.93	61.05 ± 14.36	56.62 ± 16.62
Outcome [e]	**Fail**	35	67	31	135
	Pass	108	185	208	501

[a] number of individuals enrolled in course
[b] number of individuals that accessed the CCVT and attempted pre and post quizzes
[c] CCVTs dichotomised according to median engagement (as for Table 1a).
[d] mean ± standard deviation (out of 100)
[e] outcome determined by pass/fail: fail < 50; pass ≥ 50

Table 2a - Pre vs. Post quiz: Semester 1, 2015 (combined campuses)

CCVT quizzes		Mean score (%)	Mean diff. (%)	SE mean diff.	*P*
	Pre	52.14			
1	**Post**	67.03	14.888	2.218	.000
	Pre	61.16			
2	**Post**	64.78	3.623	1.835	.052
	Pre	64.32			
3	**Post**	53.76	-10.563	3.414	.003
	Pre	76.46			
4	**Post**	78.90	2.434	2.795	.387
	Pre	56.49			
5	**Post**	85.68	29.189	2.440	.000
	Pre	59.88			
6	**Post**	67.44	7.562	2.523	.004
	Pre	89.23			
7	**Post**	79.74	-9.487	1.787	.000
	Pre	62.81			
8	**Post**	63.44	0.625	2.281	.785
	Pre	68.70			
9	**Post**	76.85	8.150	2.641	.003
	Pre	70.13			
10	**Post**	78.35	14.888	2.218	.000

Table 2b - Pre vs. Post quiz: Semester 2, 2015 (combined campuses)

CCVT quizzes		Mean score (%)	Mean diff. (%)	SE mean diff.	*P*
	Pre	42.50			
1	**Post**	39.62	-2.883	1.969	.146
	Pre	49.24			
2	**Post**	44.23	-5.008	2.177	.024
	Pre	59.83			
3	**Post**	69.17	9.335	1.912	.000
	Pre	47.69			
4	**Post**	58.19	10.504	2.987	.001
	Pre	53.38			
5	**Post**	65.41	12.030	2.987	.000
	Pre	57.14			
6	**Post**	67.70	10.559	3.336	.003
	Pre	34.04			
7	**Post**	43.47	9.422	3.456	.009
	Pre	49.80			
8	**Post**	63.89	14.087	2.718	.000
	Pre	50.49			
9	**Post**	72.17	21.675	2.860	.000
	Pre	57.81			
10	**Post**	75.00	17.188	2.549	.000

Table 3a Overall marks: Semester 1, 2015 (out of 100)

CCVT engagement (versus 0)	Mean [a]	Mean Diff. [a] ± SE [b]	95% CI [c]	*P* [d]
0	59.77			
1-3	68.76	8.999 ± 1.804	(5.46 – 12.54)	.000
4-10	76.41	16.64 ± 1.386	(13.90 – 19.38	.000

[a] = final mark (out of 100)
[b] = Standard Error
[c] = 95% Confidence Intervals
[d] = *P* value <0.05

Table 3b Overall marks: Semester 2, 2015 (out of 100)

CCVT engagement (versus 0)	Mean [a]	Mean Diff. [a] ± SE [b]	95% CI [c]	*P* [d]
0	53.09			
1-3	61.99	8.909 ± 1.690	(4.85 – 12.97)	.000
4-10	69.23	16.148 ± 1.882	(11.63 – 20.67	.000

[a] = final mark (out of 100)
[b] = Standard Error
[c] = 95% Confidence Intervals
[d] = *P* value <0.05

Table 4a Overall grade: Semester 1, 2015

Main effect	Quiz engagement	N	OR (95% CI)	*P* [a]
Pass/Fail	0	449	ref	-
	1-3	84	2.388 (1.155 – 4.936)	0.019
	4-10	96	8.883 (2.754 – 28.648)	0.000

[a] = *P*<0.05

Table 4b Overall grade: Semester 2, 2015

Main effect	Quiz engagement	N	OR (95% CI)	*P* [a]
Pass/Fail	0	448	ref	-
	1-3	105	2.126 (1.837 – 5.318)	0.000
	4-10	81	6.301 (2.965 – 13.392)	0.000

[a] = *P*<0.05

CCVT qualitative student responses

Overall student satisfaction regarding the CCVTs was 4.3 (mean; StDev 0.9) out of a 5 point Likert-scale for both semesters respectively. Student satisfaction was also evident in the qualitative open-text responses. Verbatim quotes are provided below to illustrate the tenor of student responses. Responses indicate that the CCVTs may help to alleviate the stresses

associated with summative assessment. Moreover, none of the student responses indicated that the CCVTs were additional time/effort around course content, even though they may have added to study time and thus 'time on task' (Lizzio & Wilson, 2013).

"The online video tutorials and online quizzes really helped to grasp the concepts"
"The online tutorials were a godsend. Fantastic addition to the course and really helped solidify learning"
"The non-assessable questions within the online tutorials helped remove the stress of grading, allowing me to see where I went wrong straight away, and give another chance to answer the initially incorrect question with the right answer"

Discussion

The use of online concept captured video tutorials (CCVTs) within a bioscience course of an undergraduate nursing programme was deemed, overall, a useful learning resource by those students who engaged with it. Furthermore, use of these online supplemental resources was strongly correlated with enhanced course outcomes and student satisfaction for a large, self-confessed 'science-phobic', cohort of health students. This finding indicates that engaging students with concise online video resources may promote better student outcomes; this mode of teaching does not require extensive face-to-face teaching commitments and the associated costs. It is important to note that it is difficult to separate and identify motivated and high achieving students - who may inherently perform well within the course – from other students who directly benefited from the intervention. However, unlike some other learning resources that have been documented, there appears to be both objective and subjective student benefit to the provision of these online learning tools (Johnston et al., 2015; A. McVicar, S. Andrew, & R. Kemble, 2014; Reinke, 2014). While student anxiety was not directly measured in this study, qualitative response data indicates that the incorporation of self-paced formative assessments – associated with CCVTs – reduced the stress commonly associated with summative assessment. This has been reported previously in the literature (Zakrzewski & Bull, 1998).

Currently, the range and number of online resources tailored for beginner *clinical* students in the biosciences is limited (Johnston et al., 2015; A. McVicar et al., 2014; Nicoll & Butler, 1996; Reinke, 2014). An online repository of bioscience-related CCVTs and associated online assessment items for nursing students provides a simple, relevant, cost- and time- effective solution to this problem. Research by Trnobranski (1996) and others shows that nursing students need convincing of the relevance of the bioscience in nursing practice (Gordon & Hughes, 2013; Reinke, 2014; Trnobranski, 1996). Thus, effective online learning based on the principles of constructivism, as suggested by Kala and colleagues (2010) will allow nursing students to understanding knowledge, link this knowledge to context (practice) and facilitate their motivation for a journey of discovery and construction (Kala et al., 2010).

A decline in CCVT engagement was observed across the semester (CCVT1-10), this may reflect a decline in attendance/engagement with the programme's associated learning activities (face-to-face and online), as opposed to a perceived lack of the interventions utility as a learning tool (Van Blerkom, 1992). The overall low usage rate may speak to the time pressures that impinge on nursing students; regardless, participating students were highly satisfied with the CCVTs. Increased student satisfaction has been previously reported as a function of designing fair and engaging assessment items (Lizzio & Wilson, 2013).This effect of enhancing student

success through engagement has been described with distance health (nursing) students previously (Cox & Crane, 2014), and is another reason why educators should use educational research to best develop teaching material and methods.

Limitations of this study include an inadequate means to evaluate the suitability of videos and pre/post quiz questions prior to implementation. However, performing this study on a large cohort provides a measure of internal quality control and allows for the identification of potentially unsuitable videos and questions. Such measures of continual tool evaluation will promote evidence-based CCVT development and will further improve these learning tools. Furthermore, ongoing evaluation will decipher which concepts (linked to CCVTs) students are finding difficult, and enable course and curriculum refinement to meet the learning needs of individual students and student cohorts (Salvage-Jones, Hamill, Todorovic, Barton, & Johnston, 2016). Due to student data remaining de-identified throughout this study, it was not possible to identify students and correlate their outcome with an objective grade position average or overall position score – this will be the focus of future research.

These resources are both time and cost effective, reducing temporal demand and economic burden for both academics and students. Incorporating these, or similar, resources into an existing programme offers a viable, and demonstratively beneficial, value add. (Gordon & Hughes, 2013).

Finally, the results demonstrate that CCVTs are a flexible online tool that both engaged and motivated students throughout two semesters of undergraduate nursing bioscience courses. This highlights that CCVTs can assist with the mastery of learning concepts/outcomes. This notion is congruent with principles that promote excellence in learning and teaching practice (Lizzio & Wilson, 2013). Furthermore, CCVTs appeared to present challenging learning concepts/outcomes in an enjoyable and interesting way through the use of technology that was positively evaluated by the student participants. Our data suggest that the repeatability and ongoing formative self-assessments associated with each video tutorial will allow students to work at their own pace whilst providing useful success criteria which should promote self-confidence and reduce some of the anxieties aforementioned (Cox & Crane, 2014; A. McVicar et al., 2014).

In conclusion, flexible, adaptable, self-paced online resources can support student outcome and satisfaction within challenging bioscience courses and would translate into those courses provided to remote or distance education students. Academics need to be mindful of the contemporary student and their requirements when designing curriculum and learning resources to ensure that learning and teaching occurs most effectively (Salvage-Jones et al., 2016).

References

Andrew, S., Salamonson, Y., Weaver, R., Smith, A., O'Reilly, R., & Taylor, C. (2008). Hate the course or hate to go: Semester differences in first year nursing attrition. *Nurse Education Today, 28*(7), 865-872. doi: 10.1016/j.nedt.2007.12.007

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1).

Bye, D., Pushkar, D., & Conway, M. (2007). Motivation, interest, and positive affect in traditional and nontraditional undergraduate students. *Adult Education, 57*, 141-158.

Cox, J. L., & Crane, J. W. (2014). Shifting the focus: Increasing engagement and improving performance of nursing students in bioscience subjects using face-to-face workshops to reduce anxiety. *IJISME, 22*(7), 11-22.

Craft, J., Hudson, P., Plenderleith, M., Wirihana, L., & Gordon, C. (2013). Commencing nursing students' perceptions and anxiety of bioscience. *Nurse Education Today, 33*(11), 1399-1405. doi: 10.1016/j.nedt.2012.10.020

Elison-Bowers, P., Snelson, C., Casa de Calvo, M., & Thompson, H. (2008). Health science students and their learning environment: a comparison of perceptions of on-site, remote-site, and traditional classroom students. *Perspectives in Health Information Management, 5*, 2.

Ertmer, P., & Newby, T. (2013). Behaviorism, Cognitivism, Constructivism: Comparing Critical Features From an Instructional Design Perspective. *Performance Improvement Quarterly, 26*(2).

Glen, S. (2005). E-learning in nursing education: Lessons learnt? *Nurse Education Today, 25*(6), 415-417. doi: 10.1016/j.nedt.2005.07.001

Gordon, C. J., & Hughes, V. K. (2013). Creating relevance and credibility: New approaches for bioscience education in pre-registration nursing curriculum. *21*(2), 53-65.

Gresty, K. A., & Cotton, D. R. (2003). Supporting biosciences in the nursing curriculum: development and evaluation of an online resource. *Journal of Advanced Nursing, 44*(4), 339-349.

Harris, D. E., Hannum, L., & Gupta, S. (2004). Contributing factors to student success in anatomy & physiology: Lower outside workload & better preparation. *American Biology Teacher, 66*(3), 168-+. doi: Doi 10.1662/0002-7685(2004)066[0168:Cftssi]2.0.Co;2

Hua, L., & Weiss, A. (2013). Traditional vs. blended learning of pharmacology'. *Optometric Education, 39*(1), 28-34.

Johnston, A. N. B., Hamill, J., Barton, M. J., Baldwin, S., Percival, J., Williams-Pritchard, G., . . . Todorovic, M. (2015). Student learning styles in anatomy and physiology courses: Meeting the needs of nursing students. *Nurse Education in Practice, 15*(6), 415-420. doi: 10.1016/j.nepr.2015.05.001

Kala, S., Isaramalai, S. A., & Pohthong, A. (2010). Electronic learning and constructivism: a model for nursing education. *Nurse Education Today, 30*(1), 61-66. doi: 10.1016/j.nedt.2009.06.002

Koch, J., Andrew, S., Salamonson, Y., Everett, B., & Davidson, P. M. (2010). Nursing students' perception of a web-based intervention to support learning. *Nurse Education Today, 30*(6), 584-590.

Lizzio, A., & Wilson, K. (2013). First-year students' appraisal of assessment tasks: Implications for efficacy, engagement and performance. *Assessment and Evaluation in Higher Education, 38*(4).

McVicar, A., Andrew, S., & Kemble, R. (2014). Biosciences within the pre-registration (pre-requisite) curriculum: an integrative literature review of curriculum interventions 1990-2012. *Nurse Education Today, 34*(4), 560-568. doi: 10.1016/j.nedt.2013.08.012

McVicar, A., Andrew, S., & Kemble, R. (2014). Biosciences within the pre-registration (pre-requisite) curriculum: an integrative literature review of curriculum interventions 1990–2012. *Nurse Education Today, 34*(4), 560-568.

Nicoll, L., & Butler, M. (1996). The study of biology as a cause of anxiety in student nurses undertaking the common foundation programme. *Journal of Advanced Nursing, 24*(3), 615-624.

Reinke, N. B. (2014). Are we providing resources that stimulate engagement, active learning and academic achievement? A case study of on–campus nursing students. *IJISME, 22*(1), 1-13.

Salvage-Jones, J., Hamill, J., Todorovic, M., Barton, M. J., & Johnston, A. N. (2016). Developing and evaluating effective bioscience learning activities for nursing students. *Nurse Education in Practice, 19*, 63-69.

Stecker, T. (2004). Well-being in an academic environment. *Medical Education, 38*(5), 465-478. doi: 10.1046/j.1365-2929.2004.01812.x

Trnobranski, P. H. (1996). Biological sciences in Project 2000: an exploration of status. *Journal of Advanced Nursing, 23*(6), 1071-1079.

Van Blerkom, M. L. (1992). Class attendance in undergraduate courses. *The Journal of Psychology*, 126(5), 487-494.

Wei, C., Berkner, L., He, S., Lew, S., Cominole, M., & Siegel, P. (2009). *2007–08 National Postsecondary Student Aid Study (NPSAS:08): Student Financial Aid Estimates for 2007–08: First Look (NCES 2009-166)*. Washington, DC.: National Center for Education Statistics, Institute of Education Sciences.

Zakrzewski, S., & Bull, J. (1998). The mass implementation and evaluation of computer-based assessments. *Assessment & Evaluation in Higher Education, 23*(2), 141-152. doi: 10.1080/0260293980230203