
ORIGINAL ARTICLE

Evaluation of an online case-based learning module that integrates basic and clinical sciences

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Objective: Case-based online modules can be created to integrate basic science and clinical science knowledge. An integrated module was designed, implemented, and evaluated for student performance and perception.

Methods: Five faculty members from both basic science and clinical education departments developed an integrative, online, case-based learning module. The case involved a patient with facial asymmetry, and the student was led to a diagnosis of Bell's palsy. Material on Bell's palsy was presented in an integrated module in addition to traditional lecture for a fall cohort of students and was presented only in traditional lecture format to a winter cohort of students. Both cohorts were given the same 5 multiple-choice questions on Bell's palsy as part of a midterm exam, and the scores of these test questions were compared between cohorts. A 13-question, mixed-methods survey was given to the fall cohort to determine their perceptions of the module and their learning.

Results: Multiple-choice test question performance was equivalent between cohorts for the Bell's palsy questions (fall 2018: mean = 3.68, SD = 0.99; winter 2019: mean = 3.51, SD = 0.92). Perception survey responses indicated that students felt positively about the integrated module and that it was applicable and helpful with improving, reinforcing, and integrating basic science and clinical knowledge.

Conclusion: This study provides evidence that case-based integrated modules are perceived favorably by students and result in similar exam question performance. They can be a useful tool to help students connect information throughout the chiropractic curriculum.

Key Indexing Terms: Chiropractic; Education; Teaching; Learning

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INTRODUCTION

Since publication of the Flexner Report in 1910,¹ compartmentalization of preclinical basic sciences and clinical sciences has been common in health care education. This separation of the 2 fields often does not promote integration of the foundational basic science knowledge into the clinical presentation by the learner. Students may have difficulty appreciating the relevance of basic science concepts and how they apply to clinical decision making.^{2,3} Additionally, curricula organized this way may hamper development of critical thinking and problem-solving skills.^{4,5} Incorporating biological science knowledge into clinical science can foster the development of health professionals who are better able to effectively “integrate, synthesize, and apply knowledge” in clinical situations.⁶ A report published by the Carnegie Foundation for the Advancement of Teaching Commission in 2010 recommended that basic or formal knowledge be integrated with

clinical experience.⁷ Therefore, various health care programs have begun to implement initiatives to better integrate the instruction of basic and clinical sciences. Spencer et al³ have proposed that revisiting basic science concepts during clinical training may be a more effective way to enhance retention of these concepts and to encourage integration. Although these types of interventions are now becoming common in medical training programs, they are less utilized in chiropractic education.

Educational reform is a daunting task; however, vertical integration can be achieved on a smaller scale vs an entire curriculum revision in the form of integrated modules, in particular, modules that are framed around a clinical scenario, such as those employed in case-based learning (CBL). The value of CBL, which uses clinical cases to assist teaching, has been increasingly recognized by higher-education institutions in health-related disciplines as a means to better prepare students for clinical practice.⁸ Teaching framed around clinical case studies encourages

the development of higher-order critical thinking skills⁴ and allows learners to better connect basic science principles to clinical practice.⁹ Therefore, the teaching of basic and clinical sciences can be combined within a CBL context with the aim to improve the ability of students to integrate and apply prior knowledge.

This project was designed to evaluate the utility and student perception of an online module that integrated basic science knowledge with clinical knowledge and skills in a case-based format. We measured student perception of our module, including perceived ability to integrate and apply clinical and basic knowledge to a clinical scenario. Student performance on questions covering module-related content on a course exam was also tracked and compared to the performance of students without exposure to the module to assess whether completion of the module increased knowledge.

Our hypotheses were as follows: (1) performance of students exposed to the module on module content-related questions on a course exam would exceed the performance of students without exposure to the module, and (2) student perception of the module would be positive and increase their perceived ability to integrate basic and clinical knowledge. If these hypotheses were supported, student feedback would be used by educators to improve the current module and to guide the development of future integrated modules. Similar modules have been utilized in various medical programs, such as those within the CBL system developed at the Mayo Clinic Rochester;¹⁰ however, none to our knowledge have been developed and implemented by a chiropractic institution.

METHODS

Sample

All students in the fall cohort ($n = 108$) of our head and neck diagnosis and management course were given access to the integrative module covering Bell's palsy as an optional supplement to receiving information on the topic in traditional lecture format. One hundred and five students out of the 108-person cohort accessed the module. The winter cohort ($n = 51$) received only traditional lecture without the added module. No students from the fall cohort repeated the course in the winter. This study was considered exempt from the institutional review board by the institutional review board of the University of Western States (UWS; IORG0001188).

Module Design

The module was designed by 5 faculty members from both the basic sciences and the clinical education departments in the College of Chiropractic. This group consisted of 3 chiropractors, 1 medical doctor, and 1 PhD. A chiropractor with an MS in neuroscience created patient presentation and chief complaint sections and contributed the needed basic science foundational material throughout the module. The second chiropractor, responsible for evidence-based curricula, created a section on using evidence to inform practice and a section on reviewing taking a complete history. The MD contributed to a

section on generating a differential diagnosis list and developed the physical exam section. The third chiropractor created a final section that provided a comprehensive overview of the case. Project development and module design support were provided by the PhD group member.

The module was presented to students enrolled in the 2018 head and neck diagnosis and management course. This course is a traditional face-to-face lecture course that covers diagnosis and management of nonmusculoskeletal conditions of the head and neck. It is delivered to 2nd-year chiropractic students during the 5th quarter of the curriculum and is offered in the fall and winter.

The sections were assembled into lessons on a Moodle learning management system (Moodle Pty Ltd, West Perth, Western Australia), which is an online platform that can be tailored to create a customized learning environment. The lessons included patient presentation, chief complaint, generating a differential diagnosis list, using evidence to inform practice, past health/family health/social history, focused physical exam, and case wrap-up. Each lesson consisted of a learning objective, a learning activity, and a formative assessment. Nearly all lessons contained recorded video lectures, ranging from approximately 3½ to 13½ minutes in length, that were made using Panopto software (Panopto, Seattle, WA). Some of the recorded lectures featured videos from the chiropractor with a neuroscience degree with whom the students had neuroscience classes earlier in the curriculum, bringing the foundational information into the clinical context.

Five multiple-choice questions related to content covered in the integrative module and in the traditional lecture were included on the midterm, which also included multiple-choice questions on other topics covered in the course for both the fall and the winter cohorts and contributed to the students' overall grade for the exam. The 5 multiple-choice questions were identical in both cohorts. Student performance on these questions was used to identify any quantitative differences in performance between the 2 cohorts.

Survey Design

A survey was developed to capture student perception of their learning and overall satisfaction with the format of the integrated module. Several survey items were adapted from the validated student survey used in UWS hybrid learning courses.¹¹ Additional survey items were created using knowledge of the Bell's palsy condition using "best practice" for this type of survey.² The face validity of the survey was established by the research and institutional review board administrator at UWS and by 4 other faculty members at UWS. Cronbach's alpha for these survey items was 0.93, indicating high internal consistency in the survey instrument.

The survey was comprised of 13 statements and utilized a 5-point Likert scale (5 = strongly agree, 4 = partially agree, 3 = neither agree nor disagree, 2 = partially disagree, 1 = strongly disagree). Each statement was phrased positively describing the hypothesized benefits and outcomes of the module. The survey was administered at the

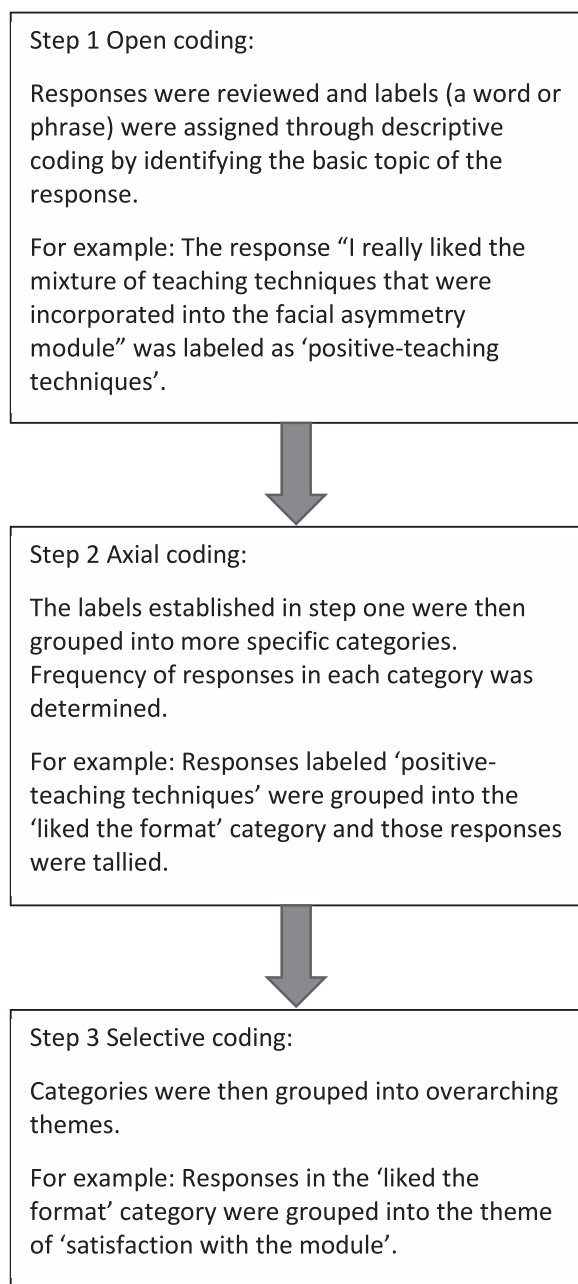


Figure 1 - Process of qualitative data analysis.

end of the integrated module. Participation was incentivized with a 1.5% increase to the final course grade. The practice of offering a small-grade inducement for the completion of a course-related survey has been reported elsewhere in the literature.^{12,13}

Survey items 1, 2, and 7–9 were related to student understanding and benefit of integrating basic science and clinical concepts. Survey items 3–6 focused on confidence and improvement in clinical skills. Survey item 10 related to ease of use. In survey item 11, students were asked their level of agreement with the following statement: “[I] prefer learning in this module format to traditional lecture format.”

Survey items 12 and 13 were open-ended questions at the end of the survey. First, in item 12, students were asked, “Please explain what you liked most about the facial asymmetry module,” and then in item 13, they were asked, “Please explain what you would change about the facial asymmetry module.”

Quantitative Data Analysis

Students in the fall cohort were given a 65-question exam covering material taught during the first 4 weeks of the head and neck diagnosis and management course. This exam contained 5 multiple-choice questions that tested knowledge pertaining to the neuroanatomy, patient presentation, diagnosis, and management of Bell’s palsy. These exam topics were presented in both the face-to-face lecture course and the online module to the fall cohort.

All students who had access to the module took the exam and answered all 5 of the questions. Student test responses specific to Bell’s palsy–related content were evaluated for correctness. Correct test responses were assigned a value of 1, and incorrect test responses were assigned a value of 0, making 5 the highest possible score. To determine if there was a statistical difference in student performance between the group that received the additional module and the group that did not, an independent-sample *t* test was conducted using IBM SPSS statistical software, version 23 (IBM Corp, Armonk, NY).

Student Likert scale question responses on perception survey items 1–11 were tallied. The percentage was then determined for each of the 5 points on the Likert scale.

Qualitative Data Analysis

Content analysis was used to evaluate the responses to the open-ended survey items and was guided by a procedure outlined by Miles et al¹⁴ (Fig. 1). The open-ended items were number 12, “Please explain what you liked most about the facial asymmetry module,” and number 13, “Please explain what you would change about the facial asymmetry module.” Responses for each item were reviewed, and through open coding, key words and phrases were established as labels for each survey item response. Labels were then grouped into categories by axial coding, and responses in each category were tallied. Finally, through selective coding, authors established overarching themes by grouping categories. Content analysis was conducted by 2 of the authors, first independently and then collaboratively.

RESULTS

Quantitative Data

As determined by the *t* test, there was no statistically significant difference ($p = .31$; 95% confidence interval = $-.16-.50$) in multiple-choice question performance between the fall of 2018 ($n = 106$, mean = 3.68, SD = 0.99) and the winter of 2019 ($n = 51$, mean = 3.51, SD = 0.92) cohorts. These results suggest that an optional, supplemental module does not influence performance on multiple-choice test questions.

Table 1 - Results of Survey Items 1–11

Survey Item	n (%)				
	Strongly Agree	Partially Agree	Neither Agree nor Disagree	Partially Disagree	Strongly Disagree
Able to integrate basic sciences and clinical knowledge in a common context	56 (55.4)	37 (36.6)	5 (5)	1 (1)	2 (2)
Understand the relationship between neuroanatomy and clinical diagnosis	70 (67.3)	25 (24)	5 (4.8)	2 (1.9)	2 (1.9)
Broader understanding of the diagnosis process from start to finish	73 (70.9)	23 (22.3)	5 (4.9)	0 (0)	2 (1.9)
More confident in my ability to take a history from a patient	46 (44.2)	38 (36.5)	15 (14.4)	3 (2.9)	2 (1.9)
More confident in my understanding of selecting exam procedures	37 (35.6)	47 (45.2)	13 (12.5)	7 (6.7)	0 (0)
Improved my ability to quickly search for evidence-based information	44 (42.3)	39 (37.5)	13 (12.5)	5 (4.8)	3 (2.9)
Concepts of basic sciences in module helped more easily understand the signs and symptoms of Bell's palsy	71 (68.3)	25 (24)	6 (5.8)	0 (0)	2 (1.9)
Concepts of basic sciences integrated with concepts of clinical sciences helped differentiate the diagnosis of Bell's palsy from other diagnoses	71 (68.3)	23 (22.1)	7 (6.7)	1 (1)	2 (1.9)
Module helped me to learn about Bell's palsy in a more comprehensive way	74 (71.2)	22 (21.2)	6 (5.8)	0 (0)	2 (1.9)
The Bell's palsy module was easy to follow	73 (70.2)	23 (22.1)	4 (3.8)	1 (1)	3 (2.9)
Prefer learning in this module format to traditional lecture format	29 (28.2)	39 (37.9)	25 (24.3)	7 (6.8)	3 (2.9)

In the fall of 2018, 105 students responded to the survey regarding their perception and satisfaction with the Bell's palsy module. In some cases, not all 105 respondents answered each question. Items 1–8 asked student respondents to evaluate the content within the module and their reaction to the content (Table 1). The theme of integration was recognized by the students in that 92% felt able (strongly or partially) to integrate basic science and clinical knowledge in a common context. Regarding diagnosis, 92.9% of students strongly or partially agreed that they had a broader understanding of the diagnosis process from start to finish. The results indicate that 80.7% and 80.8% of students agreed, either strongly or partially, that the module increased confidence in history taking and

selection of exam procedures. Evidence-based skills were also influenced, as 79.8% of students believed that the module positively impacted their ability to rapidly search for evidence-based information.

The final 3 Likert survey items 9–11 prompted the student to evaluate the use of the module in a holistic way. A large portion of students, 92.4%, strongly or partially agreed that the module promoted comprehensive learning by integration of basic and clinical concepts. The final item showed that 66.1% agreed (strongly or partially) that they preferred learning in the module rather than in a lecture. Notably, 25% had no preference, neither agree or disagree, about learning in a module or in a traditional lecture.

Table 2 - Content Analysis of Open-Ended Question 12, "Please Explain What You Liked Most About the Facial Asymmetry Module"

Theme	Satisfaction With the Module	No. of Occurrences
Categories	Liked the online format	54
	Overall enjoyment/interactive	41
	Easy to follow	31
Theme	Perceived Result of Using the Module	No. of Occurrences
Categories	Improved clinical knowledge	34
	Applicable to patient care	29
	Integrated basic science and clinical knowledge	20

Qualitative Data

Open-ended survey item 12, "Please explain what you liked most about the facial asymmetry module," generated 105 responses. All student responses were reviewed thoroughly, and each was given 1 or more labels, as some responses contained more than 1 topic. Labels were words or phrases included in a response. Responses such as "I liked the way it was set up overall and the addition of videos was great" was labeled as setup/videos, and "This was a great overview of how to take a history and use that information to form a diagnosis" was labeled as overview of history taking/diagnosis formation. The first 3 categories made up the overall theme of "satisfaction with the module," and the remaining 3 categories made up the theme of "perceived result of using the module." Categories and results for the 6 labels are shown in Table 2.

Table 3 - Content Analysis of Open-Ended Question 13, “Please Explain What You Would Change About the Facial Asymmetry Module”

Theme	No Change	No. of Occurrences
Categories	No need for improvement	35
	More modules like this	7
Theme	Change the Content	No. of Occurrences
Categories	Need examples	20
	Add detail	18
Theme	Change the Format	No. of Occurrences
Categories	Usability	21
	Assessment	10

Open-ended survey item number 13, “Please explain what you would change about the facial asymmetry module,” generated 105 responses. Once again, all student responses were reviewed and were assigned labels based on the main topic(s) of the response. Responses such as “Nothing, I really enjoyed it” were labeled as no change, and “I would add videos of a doctor performing diagnostic tests on a patient” was labeled as add demo videos.

Six categories were developed from the labels and included *no need for improvement*, *more modules like this*, *need examples*, *add detail*, *usability*, and *assessment*. Three overarching themes emerged from these categories: (1) no change, (2) change content, and (3) change format. The theme of no change included the categories *no need for improvement* and *more modules like this*. The theme change content included the categories *need examples* and *add detail*. The theme change format included the categories *usability* and *assessment*. Categories and results are presented in Table 3.

DISCUSSION

To our knowledge, this study is the first of its kind to evaluate the utility of an online module that integrated basic and clinical science information in a case-based format within a chiropractic program. There was no significant difference in the multiple-choice question performance of students that had access to the integrated module content compared to students without access. It is possible that this result is due to the method of assessment as well as the selected questions. The multiple-choice exam questions that we utilized required primarily factual recognition only. Students may more readily demonstrate conceptual understanding of how basic science concepts are integrated into a patient’s clinical presentation with very-short-answer, short-answer, or essay formatted questions, as these question types can be written so that they require a student to analyze or evaluate a clinical scenario.¹⁵ Furthermore, Sam et al¹⁶ demonstrated evidence that very-short-answer questions may better evaluate a student’s clinical knowledge than single-best-answer

multiple-choice questions, as students are unable to utilize test-taking strategies that rely on the answer list, such as simple word association. Changing the assessment format may provide better insight into whether there was improved comprehension of diagnosis and management processes among students with access to the module.

It is important to note that a majority of students perceived that the module facilitated their ability to connect the basic science of neuroanatomy to the clinical diagnosis of Bell’s palsy. Students at medical schools that have implemented various methods to integrate basic and clinical sciences report similar perceptions of improved ability to make connections between basic and clinical sciences as well as an enhanced ability to understand and apply the content.^{6,17} Additionally, our students perceived that integrating basic science concepts with clinical concepts helped them understand both the symptoms and the etiology of Bell’s palsy as well as their ability to differentially diagnose patients presenting with facial asymmetry. This finding is significant because, as educators, one of our goals is to impress on the students the interrelatedness of the foundational basic science content and clinical diagnosis. It is often difficult to achieve this goal in a compartmentalized program where basic sciences are taught first, followed by clinical skills. Modules like this one allow the clinical educator to bring foundational material into clinical case presentations and deliberately and clearly link basic science to clinical concepts in a way that has not been done before in chiropractic education. This connection is enhanced by using both the presence of the basic science educator and the content they have previously delivered.

Notably, exposure to the module appeared to increase student confidence in their ability to take a history and select appropriate exam procedures. Moreover, the module had positive crossover effects on the overall process of diagnosis with over 90% of students reporting a broader understanding of patient evaluation from start to finish. Students also perceived that the module promoted comprehensive learning through integration of basic and clinical sciences. These student perceptions may reveal that students gained a deeper level of learning that goes beyond simply selecting correct answers on an exam and could lead to better generalizability of the lessons of the module to the assessment and diagnosis of other conditions. Deeper learning has previously been proposed as an advantage of vertical integration of basic and clinical sciences.^{18,19}

Most student responses about the module were positive, and ~66% preferred learning in the module rather than in a traditional face-to-face lecture format. However, 25% had no preference, neither agree nor disagree, about learning in a module compared to in a traditional lecture. This reflects the diversity of student learning preferences within a large population. The use of the online delivery appeals to many of the students but, predictably, not to others. Wilkins et al²⁰ postulated that learning preferences may have influenced student engagement with an integration method that utilized an online component at the Yale School of Medicine. Courses, both basic science and

clinical, that offer a variety of ways to attain knowledge may be more desirable to the current student population.

Although basic and clinical science integration has been a theme of curricular reform consistently in medical education for nearly the past decade, it has only recently been incorporated into chiropractic education. This integrated module is the first of its kind to be developed for a chiropractic institution. Similar to allopathic doctors, chiropractors must be able to accurately assess and diagnose a multitude of medical conditions. Understanding the relationship of basic science principles to disease etiology may improve diagnostic accuracy.²¹ Access to resources, such as similar integrated modules, may allow chiropractic students to better hone these skills while providing a satisfying learning experience. Future modules could be developed around conditions most commonly encountered by chiropractors so that students may learn through modeling of the entire diagnostic process. Modules could also be incorporated throughout the curriculum so that this type of vertical integration is more consistent.

Limitations

There are several limitations of this study. One limitation of this study was that the participants were selected on the basis of enrollment and therefore not randomized. The results of this study may not be widely generalizable to other institutions outside of chiropractic education. The multiple-choice questions that assessed knowledge of Bell's palsy were part of a larger exam. It may be that these questions should have been a separate assessment to more accurately determine if the module impacted learning. Finally, although the majority of students (105 out of 108) completed the module, it was not a required or graded activity, and this may have limited student engagement with the content and diminished its overall impact on exam question performance. In the future, the module could be a required graded portion of the course and could potentially enhance engagement.

CONCLUSION

The reception by chiropractic students of an online integrated module was overwhelmingly positive. Creation of additional modules to help students synthesize basic science concepts with patient evaluation and management seems to be a valuable teaching method.

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