The Flipped Classroom With Case-Based Learning in Graduate Nurse Anesthesia Education

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A pilot study was conducted to compare student academic performance and course satisfaction with the flipped classroom (a type of blended learning) and case-based learning in a graduate nurse anesthesia program. Quiz, test, and student satisfaction survey scores from a neuroanesthesia principles course were compared between 2 first-year nurse anesthesia student cohorts taught in a flipped classroom with case-based learning (n=17) vs traditional lecture-based classroom (n=19). Mean preclass and postclass quiz scores (SD) improved significantly in both the flipped classroom (8.41 [0.870] vs 8.94 [0.243], P=.03, α=.05) and traditional classroom (8.68 [0.58], P=.03, α=.05). Between cohorts, no significant differences were found on mean preclass (8.68 vs 8.68, P=.34, α<.05) and postclass quizzes (8.94 vs 9.0, P=.32, α<.05) or examination scores (29.41 [2.00]; 28.31 [2.14]; P=.12, α<.05). Student satisfaction scores were favorable but not significantly different between cohorts. Based on noninferior outcomes in student academic performance and satisfaction, the flipped classroom with case-based learning may be a suitable alternative to the traditional lecture-based classroom in graduate nurse anesthesia education.

Keywords: Anesthesia, case-based learning, flipped classroom, graduate nursing education.

Nurse educators have identified a need to transform nursing education to close the gap between didactic education and clinical performance and to better prepare nursing students who can learn and function competently in today’s increasingly complex, unpredictable healthcare environment. In a landmark study of nursing education in the United States, researchers found that despite dramatic increases in the complexity of patient care over the past 4 decades, nursing education had largely remained unchanged. Nurse educators have relied heavily on traditional lecture-based teaching methods with rote memorization of facts, creating a separation between knowledge acquired in the classroom and skills demanded for clinical practice. Therefore, researchers recommended educational techniques that integrate didactic and clinical learning by teaching salient critical reasoning skills and formation into the role of professional nurse. These recommendations were consistent with calls to transform nursing education put forth by the Institute of Medicine (now called the National Academy of Medicine) and the National League for Nursing.

As advanced practice nurses, nurse anesthesia educators share a similar desire to transform the education of graduate-level student registered nurse anesthetists (SRNAs) to ensure quality education by the best possible means. Although traditional methods of education have produced highly competent nurse anesthetists in the past, today’s healthcare environment is changing rapidly, and nurse anesthetists must keep pace with a growing knowledge base and skill set. The requisite skills to do so, such as critical reasoning, problem solving, and collaboration, are not easily taught with the prevailing traditional lecture-based education model. Therefore, nurse anesthesia educators are seeking alternative evidence-based educational models to develop these essential skills and better prepare graduates for clinical practice in an evolving, complex healthcare environment.

• Alternate Educational Models. The flipped classroom and case-based learning are 2 active learning methods that have been proposed for nurse anesthesia education based on prior use in healthcare education. The flipped classroom is a pedagogical model that inverts traditional lecture and homework elements of a course. Students view prerecorded lectures and course materials before attending class and then spend class time on interactive learning exercises to apply knowledge with the guidance of the instructor. This method places responsibility for learning on students, allows students to work at their own pace, gives instructors greater insight into student learning needs, and leads to greater student interest and engagement in the classroom. Case-based learning is an in-class activity that can be used within the flipped classroom model, where students work in groups to answer questions related to unfolding clinical case scenarios. By doing so, students apply preexisting knowledge along with new knowledge gained from preclass assignments to solve real-world clinical problems through collabora-
tion and class discussion.11 Through case-based learning activities, students also develop clinical reasoning skills by learning to organize, recall, and apply clinical information at appropriate times.

The constructivist learning theory provides a theoretical framework to support the use of the flipped classroom with case-based learning in nurse anesthesia education. Cognitive and social constructivism are 2 components of constructivist learning theory that are operationalized in this educational model.12-14 Cognitive constructivism proposes that individuals form knowledge and meaning through analyzing and interacting with the environment. When an individual reconciles new information with previous knowledge or understanding, new knowledge is formed. In a flipped classroom, students reconcile prior clinical knowledge to new information presented in preclass course materials, thus constructing new knowledge. According to social constructivism, individuals learn through social interaction with higher performing peers and exposure to the thought processes of others.12,15 During case-based learning exercises, students learn from each other in a social context by sharing clinical knowledge, experiences, ideas, and newly formed understandings with each other as they answer questions related to an unfolding case scenario. As part of the information exchange process, students may also learn from classmates who function at higher cognitive levels.

• Review of Literature. Searches of PubMed, Embase, Cumulative Index to Nursing & Allied Health Literature (CINAHL), ERIC (Education Resources Information Center), and Scopus electronic databases using the keywords flipped classroom, nursing education, anesthesia, graduate, and case-based learning were conducted to find research articles related to the flipped classroom and to case-based learning. The search was limited to articles published in English in peer-reviewed journals between January 1, 2012, and December 31, 2019. Nursing research articles that measured academic performance and student satisfaction in the flipped classroom with case-based learning were retained for review. A total of 135 articles were retrieved. After removal of duplicates and screening based on inclusion criteria, 15 were retained for final review.

Comparisons of student academic performance measured by quiz and test scores between the flipped classroom and traditional lecture-based classroom yielded mixed results. In some cases, student quiz and test scores were significantly higher in flipped classroom cohorts than in traditional classroom cohorts, whereas in others no significant differences were found.7,8,16-24 Only 1 study found varying results from multiple unit tests and final examination scores between a flipped vs traditional classroom.19 On half of the examinations, students in the flipped classroom scored significantly higher, whereas on the other half students in the traditional classroom scored higher. However, there were no significant differences in average final grades between the cohorts. Across studies, in-class learning activities in flipped classrooms varied widely and included combinations of case-based learning, think-pair-share, role play, group discussion, and learning laboratories.16,17,20,22,23 In some studies, descriptions of in-class activities were uncited or not described at all.7,8,18-20,22

Student satisfaction with the flipped classroom vs traditional classroom was mixed. When satisfaction survey results were primarily favorable, students reported positive perceptions of learning, better understanding of course material, and improved ability to apply knowledge.16,17,23 Students also appreciated opportunities for discussion and interaction with instructors.8 In 2 semester-long studies that measured student satisfaction during and at the end of flipped courses, satisfaction levels were initially low but increased by classes' end.21,24 Investigators concluded that students needed time to adjust to the new course format. Instructors also made changes based on students' interim feedback.24 In other studies, students were dissatisfied with the flipped classroom because of the increased workload of preclass assignments, technological difficulties, and instructors' failure to communicate the rationale for use of a new teaching modality.7,17,19,22

Systematic and integrative reviews on efficacy of the flipped classroom teaching model were inconclusive.25-27 Authors found no compelling evidence that student academic performance improved as a result of the flipped classroom, nor evidence that student performance declined. Authors called for stronger experimental designs, larger sample sizes, and measurements of quantifiable data.

Many studies of the flipped classroom included in this review used a combination of different learning activities, including case scenarios. Therefore, the effect of case-based learning on student academic performance could not be determined.16,20,22,23 Responses to specific survey questions related to case-based exercises indicated that students were either highly satisfied or "luke-warm" toward the use of case studies.16,21,24 In contrast, a systematic review of research on case-based learning in healthcare education found no improvements in academic performance with case-based learning compared with traditional lecture-based teaching.28 However, there was evidence that both faculty and students enjoyed case-based learning. Students thought they learned better, and faculty believed that students were more engaged and motivated to learn.

In summary, evidence showed similar or improved student academic performance with the flipped classroom and case-based learning compared with the traditional lecture-based classroom. In many cases, students were highly satisfied with these 2 teaching models. Based on supporting evidence and lack of demonstrated harm,
the flipped classroom with case-based learning may be a suitable alternative to lecture-based classrooms in nurse anesthesia education. Although the ultimate aim of instituting this new educational model is to develop skills such as critical reasoning, problem solving, and collaboration, it is prudent to first measure the impact on student learning and acceptance before widespread implementation. Using similar methods from other trials found in the literature, a pilot study was conducted to answer the following research question: Is there a difference in student learning, measured by quiz and test scores, and course satisfaction between SRNAs instructed in a flipped classroom with case-based learning vs a traditional lecture-based classroom?

**Methods**

The flipped classroom with case-based learning was implemented in place of a traditional lecture-based classroom to teach neuroanesthesia theory to first-year SRNAs in a Midwestern university. Using a mixed-methods cohort comparison, outcome measures of student learning and course satisfaction were compared between 2 convenience samples of students, one taught in a flipped classroom with case-based learning (n=17) and the other taught in a traditional lecture-based classroom (n=19) the prior year. Student learning in each cohort was measured by assessing mean scores on the preclass and post-class quiz. Differences in learning between the 2 student cohorts were measured by comparing mean preclass and postclass quiz scores as well as mean scores on a subset of examination questions on neuroanesthesia theory. Student course satisfaction was also compared between the 2 cohorts using results of a university-generated survey. Demographic data, including student ages and years of experience as registered nurses and intensive care unit nurses, were also analyzed to see if the 2 groups were similar in average age and years of clinical experience. This study was approved by the institutional review board and classified as exempt from ongoing review because it involved implementation of a new educational method and use of de-identified data. Student consent to participate was not required.

**Procedure.** The class on principles of neuroanesthesia was taught in a single 4-hour session of a flipped classroom with case-based learning by the same instructor who taught the class using the traditional lecture method the year before. The instructor used guidelines described by Hawks to conduct the flipped classroom and constructed case scenarios according to a format described by faculty at Florida State University School of Medicine, Tallahassee. Case scenarios were based on actual neurosurgical cases in which the course instructor was the anesthesia provider. Class content aligned with course objectives, course assessments, and the examination content outline provided by the National Board of Certification & Recertification for Nurse Anesthetists.

Four weeks before class, the instructor briefed students on the new class format. Two weeks before class, the instructor posted class materials on the course website. Materials included class learning objectives, reading assignments, 13 prerecorded video lectures, topics for case-based learning exercises, and student work group assignments. Course content presented in the video lectures was identical to that presented in the classroom lecture the year before.

Class began with an online, closed-book quiz composed of 10 multiple-choice items, followed by a brief instructor-led question-and-answer session. Students divided into 6 preassigned groups to work an unfolding case scenario related to anesthetic management of a given neurosurgical procedure. The case scenarios were not revealed to the students until class convened. The work groups collaborated to answer interposed questions related to the various stages of each neurosurgical procedure. Afterward each group presented their cases to the class. At the end of class, students retook the 10-item quiz. As with the traditional student cohort, pre and postclass quiz results were not shared with students until after class. A minimum score of 80% was required to pass the quizzes.

Students also completed the online course satisfaction survey that was made available the next day. The survey was composed of 6 questions answered on a 4-point Likert-type scale (1=does not meet objective, 2=minimally meets objective, 3=usually meets objective, 4=completely meets objective). A final open-ended survey item allowed for student comments. The next week, students took the semester final examination, which included 36 multiple-choice questions related to principles of neuroanesthesia.

Identical quizzes, examination questions, and student course satisfaction surveys were used in both study cohorts. Quiz and examination questions were written by program faculty experts. Each were scored by program faculty, and results were shared with the course instructor after student identifiers were removed. Student course satisfaction surveys were scored by the university, and de-identified results were shared with the class instructor. Unfolding case scenarios were used as in-class learning tools to help students apply didactic knowledge into clinical practice situations. Unfolding case scenarios were not graded because outcome measures were restricted to those used in both cohorts of students.

**Data Analysis.** Statistical analyses were performed using SAS 9.4 (SAS Institute Inc). Student t tests and Wilcoxon ranked sums were used to analyze datasets where appropriate.

**Results**

Demographic data indicated that the 2 cohorts were similar regarding average ages at the time of the neuroanesthesia theory class and years of nursing experience at the
time of nurse anesthesia program application (Table 1).

Before mean preclass and postclass quiz scores were calculated, 1 item was removed from analysis because of a minor discrepancy between course content and a predetermined correct answer. As reflected in the ranges of scores from both cohorts, based on 9 items, not all students passed the preclass quiz (flipped class, n=2; traditional class, n=1) whereas all passed the postclass quiz (passing score ≥7.2 or 80%). Mean postclass quiz scores showed significant improvement from the preclass quiz in both the flipped classroom and traditional classroom (Table 2). However, there were no significant differences in aggregate mean scores on preclass or postclass quizzes between the 2 cohorts (Table 3).

Of 36 course examination questions, 4 items were removed from analysis by discretion of the program faculty at the time of grading. Based on results from the subset of 32 remaining questions, there were no significant differences in aggregate mean scores between the 2 groups (Table 4).

Thirteen (76%) of 17 students from the flipped classroom and 15 (79%) of 19 students from the traditional classroom responded to the course satisfaction survey. Because individual student responses to survey questions were not available to investigators, mean scores on each item were analyzed using an independent samples t test. There was no significant difference in students’ satisfaction survey results between the 2 educational models (Table 5). Students’ narrative comments about the flipped classroom were mixed. Students described prerecorded video lectures as comprehensive, detailed, very professional, helpful to understanding class material, and well aligned with readings. Some students commented that the number of videos was overwhelming and the content too long (total viewing time=2.7 hours). Although students stated that case-based exercises taught them how to apply principles of neuroanesthesia to various clinical situations, they also believed that case scenarios and student presentations were too long and should have been more interactive. In-class group work on case scenarios took as long as 45 minutes, and case presentations took about 25 minutes apiece (approximate total presentation time=150 minutes). Thus, group work and presentations consumed more than 3 of the 4 hours allotted for the class.

Discussion

Although favorable, student performance and course

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Table 1. Demographic Data of Student Cohorts

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>P valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>17</td>
<td>Age in N625, y</td>
<td>30.29 (3.60)</td>
<td>25</td>
<td>36</td>
<td>.45</td>
</tr>
<tr>
<td>Traditional</td>
<td>19</td>
<td>Age in N625, y</td>
<td>29.16 (5.10)</td>
<td>25</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Flipped</td>
<td>17</td>
<td>Years as RN</td>
<td>3.25 (1.70)</td>
<td>1</td>
<td>6.5</td>
<td>.2</td>
</tr>
<tr>
<td>Traditional</td>
<td>19</td>
<td>Years as RN</td>
<td>2.61 (1.23)</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Flipped</td>
<td>17</td>
<td>Years in ICU</td>
<td>2.37 (1.47)</td>
<td>1</td>
<td>6.5</td>
<td>.35</td>
</tr>
<tr>
<td>Traditional</td>
<td>19</td>
<td>Years in ICU</td>
<td>1.97 (1.03)</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ICU, intensive care unit; RN, registered nurse.

Note: aStudent t test, α < .05.

Table 2. Comparison of Preclass and Postclass Quiz Scoresa

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean preclass score (SD)a</th>
<th>Range</th>
<th>Mean postclass score (SD)b</th>
<th>Range</th>
<th>Change</th>
<th>95% CI for change</th>
<th>P valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>8.41 (0.87)</td>
<td>6-9</td>
<td>8.94 (0.24)</td>
<td>8-9</td>
<td>0.53</td>
<td>(0.04-1.01)</td>
<td>.03</td>
</tr>
<tr>
<td>Traditional</td>
<td>8.68 (0.58)</td>
<td>7-9</td>
<td>9.0 (0.0)</td>
<td>—</td>
<td>0.32</td>
<td>(0.04-0.60)</td>
<td>.03</td>
</tr>
</tbody>
</table>

Note: aMaximum possible score=9.

Table 3. Comparison of Mean Preclass and Postclass Quiz Scores Between Cohorts

<table>
<thead>
<tr>
<th>Quiza</th>
<th>Flipped class (n=17)</th>
<th>Traditional class (n=19)</th>
<th>P valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preclass</td>
<td>8.41</td>
<td>8.68</td>
<td>.34</td>
</tr>
<tr>
<td>Postclass</td>
<td>8.94</td>
<td>9.00</td>
<td>.32</td>
</tr>
</tbody>
</table>

Note: aMaximum possible score=9.

Discussion

Although favorable, student performance and course
satisfaction were similar between students taught in a flipped classroom with case-based learning vs a traditional lecture-based classroom. There were no significant differences found in comparisons of mean preclass and postclass quiz scores between the 2 student cohorts. Similar outcomes on preclass quiz scores implied that preclass preparation with assigned readings and prerecorded video lectures offered no apparent benefit. Although not statistically significant, mean preclass quiz scores were slightly lower in the flipped classroom. Whether all students prepared for class by reading assigned materials and/or viewing all prerecorded video lectures was unknown. Perhaps this student cohort scored lower because a new teaching method was implemented in a content-laden, complex course such as neuroanesthesia theory. Also, the course was held at the end of the semester, 1 week before final examinations, in the flipped classroom cohort. Impending final examinations may have affected students’ ability or willingness to complete preclass work for the flipped classroom. Whether all students prepared for class by reading assigned materials and/or viewing all prerecorded video lectures was unknown. Perhaps this student cohort scored lower because a new teaching method was implemented in a content-laden, complex course such as neuroanesthesia theory. Also, the course was held at the end of the semester, 1 week before final examinations, in the flipped classroom cohort. Impending final examinations may have affected students’ ability or willingness to complete preclass work for the flipped classroom. Postclass quiz scores were significantly higher than preclass quiz scores in both cohorts, indicating that both case-based learning and lectures had a positive impact on student learning.

Students in the flipped classroom scored slightly higher on the course examination questions, although the difference was not statistically significant. It is not possible to determine if scores were affected by the flipped classroom model. In the study cohort, students received course content 1 week before the final examination. In the traditional cohort, the course was held in the middle of the semester, and students were tested on the material twice—one on a unit test and again on the final examination. The timing of the course and repeated testing on the same material in the traditional cohort pose confounding influences on comparisons of test question scores.

No significant differences were found in course satisfaction between the 2 cohorts. Students in the flipped classroom gave the highest mean satisfaction scores to clarity and pertinence of course materials presented. Students were slightly less satisfied with the flipped classroom with respect to learning materials provided, instructor openness to questions, and future interest in the instructor. Since classroom lectures were the predominant teaching method used in the program curriculum, students may not have been accustomed to a new way of learning course material. Students in the flipped classroom gave the lowest mean score to the amount of material presented in the allotted time. Open-ended comments on the survey aligned with aspects of the class that students were most and least satisfied with. Both student cohorts were least satisfied with the amount of material presented in the course, with nearly identical mean item scores. Although mean scores on this survey item were lowest, they were nonetheless favorable.

Findings from this pilot study suggested that the flipped classroom with case-based learning is a noninferior active learning educational model and a possible alternative to traditional lecture-based classroom in nurse anesthesia education. Study outcomes were consistent with prior research on student performance and satisfaction in nursing education. In this study, student performance and course satisfaction were already high among students taught in the traditional classroom, so it may have been difficult to demonstrate significant improvements.

Student comments on the course satisfaction survey provided valuable feedback to improve future classes and guide wider implementation of this new educational model into the program curriculum. In the future, prerecorded video lectures should be shortened and limited to material relevant to class. Information relevant to the

### Table 4. Mean Scores on Neuroanesthesia Examination Questions

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Mean total score (SD)</th>
<th>Minimum score</th>
<th>Maximum score</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>17</td>
<td>29.41 (2.00)</td>
<td>25</td>
<td>32</td>
<td>.12</td>
</tr>
<tr>
<td>Traditional</td>
<td>19</td>
<td>28.31 (2.14)</td>
<td>25</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

*a* Maximum possible score=32.

*b* Student t test, α < .05.

### Table 5. Student Course Satisfaction: Survey Results

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Traditional class</th>
<th>Flipped class</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture topic was pertinent to course material</td>
<td>3.87 (0.352)</td>
<td>3.92 (0.277)</td>
<td>.65</td>
</tr>
<tr>
<td>Lecturer was organized, expressed concepts clearly</td>
<td>3.93 (0.258)</td>
<td>3.92 (0.277)</td>
<td>.92</td>
</tr>
<tr>
<td>Lecturer presented appropriate amount of material in allotted time</td>
<td>3.53 (0.743)</td>
<td>3.54 (0.519)</td>
<td>.98</td>
</tr>
<tr>
<td>Lecturer was open to questions, discussion of ideas during class</td>
<td>4.00 (0)</td>
<td>3.77 (0.439)</td>
<td>.08</td>
</tr>
<tr>
<td>Audiovisual aids and handouts were helpful</td>
<td>3.93 (0.258)</td>
<td>3.77 (0.439)</td>
<td>.23</td>
</tr>
</tbody>
</table>

*a* Maximum possible score=4.

*b* Independent samples t test, α < .05.
case setup could be offloaded into optional videos for students to view during their clinical neuroanesthesia rotations instead of before class. Unfolding case scenarios could be shortened to reduce class time, offset time spent on viewing prerecorded video lectures, or allow for other active learning exercises.

Since quiz and test scores do not measure clinical abilities, different outcome measures, such as critical reasoning, problem solving, and knowledge retention might show benefits to the flipped classroom over the traditional classroom. In place of quizzes, rubrics could be used to measure student learning and ability to apply didactic information to clinical situations through unfolding case scenarios in the classroom or simulation laboratory. Future studies could also measure differences in critical reasoning, problem solving, collaboration, and knowledge retention between nurse anesthesia students taught in flipped vs traditional classrooms.

The investigators acknowledge several limitations to this study. Students in the study group had limited exposure to the flipped classroom in a single 4-hour course. Given curricular restraints, time limitations, and small cohorts of students that are characteristic of nurse anesthesia programs, conducting a randomized controlled trial of this new educational model was not feasible. Outcome measurements of the flipped classroom with case-based learning were constrained to those used in the prior year's traditional classroom and not constructed to measure student ability to apply knowledge to clinical situations. However, quiz and test scores are commonly used outcome measures in studies of the flipped classroom. Since course grades and progression through a nurse anesthesia program are partly determined by scores on quizzes and tests, it is reasonable to use such measures in pilot studies to determine the success of the flipped classroom.

The course satisfaction survey was not designed to evaluate a flipped classroom with case-based learning. Only 1 open-ended question allowed students to make specific comments on this educational model. Information on reliability and validity of the survey was not available. Results of this study were limited to a single university setting and may not be generalizable elsewhere. The course instructor was a staff Certified Registered Nurse Anesthetist and guest lecturer who implemented the flipped classroom and case-based learning under guidance of the nurse anesthesia program director and faculty of record for the semester-long course that included principles of neuroanesthesia. Although the instructor successfully taught principles of neuroanesthesia and other courses using the traditional lecture-based teaching model to past student cohorts, she did not hold a formal position as a nurse anesthesia program faculty member. Yet student academic performance and course satisfaction were similar to the prior year's student cohort taught by the same instructor using the traditional lecture-based model.

Conclusion

Based on outcome measures of student academic performance and satisfaction, the results of this pilot study of a flipped classroom with case-based learning suggested that this educational model may be a suitable alternative to the traditional lecture-based classroom in nurse anesthesia education. Lessons learned through this pilot study highlighted areas for improvement regarding implementation and the need for more robust research in nurse anesthesia education. Future studies are needed to test the effects of the flipped classroom model on skills necessary for nurse anesthesia clinical practice in an evolving and increasingly complex healthcare environment.

REFERENCES