Improvement in Student Performance and Perceptions through a Flipped Anatomy Classroom: Shifting from Passive Traditional to Active Blended Learning

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One of the major challenges facing anatomy educators is delivering the anatomy materials in fewer hours with a reduction of anatomy courses in the integrated curricula. The flipped classroom modality may be an innovative solution. However, its effectiveness remains under debate due to a lack of outcome-based research and the mixed results of students' performance. The present study aimed to determine the outcome of the flipped classroom based upon the level of student cognition. The study investigated performance on 17 multiple-choice anatomy questions as a part of the final examination of the musculoskeletal system module. The results were compared between the first-year female students of Qassim Medical College, specifically the flipped classroom group (46 students) of the academic year (2018–2019) and the traditional group (49 students) of the academic year (2017–2018). The mean differences in the students' grades on the anatomy questions at the level of knowledge, application, and analysis using Cohen's *d* test were 0.43, 1.41, and 1.01, respectively. These results suggest the positive impact of flipping the students' classrooms on improving their levels of thinking according to Bloom's taxonomy. Perception surveys also revealed students' enthusiasm for the pre-class activities, leading to a better performance in the class with more engagement with their peers and teachers. The present study suggested that the flipped classroom modality can be performed to compensate for the reduction of anatomy educational hours. However, further studies are recommended to investigate the best practices of the flipped classroom that fit with the students' needs and workloads. Anat Sci Educ 0: 1–9. © 2020 American Association for Anatomy.

Key words: Gross anatomy education; flipped classroom; blended learning; students' engagement; students' performance; pre-class; online uploading; Blackboard learning management system

INTRODUCTION

Recently, many medical schools have opted to reduce the anatomy curriculum, partly as a result of the expansion of scientific knowledge and the introduction of new medical technologies (Khan, 2007; Topping, 2014; Yaqinuddin et al., 2016). In addition, the adoption of integrated curricula has led to shrinking of traditional basic science courses, including the gross anatomy lectures and cadaveric laboratories (Waterston and Stewart, 2005; Bergman et al., 2011; Kemeir, 2012). However, both clinicians and anatomists believe that adequate and precise knowledge of human anatomy is of utmost importance for safe clinical practice (Dangerfield et al., 2000; Fasel et al., 2005). Given this alarming situation, anatomy educators have begun to endorse new educational strategies in which students can actively participate and apply the important factual and clinical anatomical information within the reduced timeframe (Estai and Bunt, 2016; Morton and Colbert-Getz, 2017; Day, 2018; Fleagle et al., 2018). It has been demonstrated that learning time is much decreased when promoting students to become more active participants in their education (Ferrer-Torregrosa et al., 2016).

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Active, student-centered learning has been documented to be more effective than passive, teacher-centered traditional lectures, as active learning gives students more opportunities to problem solve and think critically (Moravec et al., 2010; Andrews et al., 2011; Pierce and Fox, 2012; Prober and Heath, 2012; Freeman et al., 2014). Among new pedagogical approaches, the flipped classroom is an innovative teaching methods that fosters student engagement (Mazur, 2009; Prober and Khan, 2013; Moffett and Mill, 2014; Bates et al., 2017; Kellesarian, 2018; Zheng and Zhang, 2020).

The flipped classroom is an inverted, blended teaching model where the interaction in the classroom and the homework are swapped (McLaughlin et al., 2014; Hurtubise et al., 2015; Moffett, 2015; O'Flaherty and Philips, 2015; Sharma et al., 2015; Prasad Kuppili and Venkatachelam, 2017; Hew and Lo, 2018). The students are asked to read from textbooks and watch lecture presentations and prerecorded video tutorials as self-directed learning (SDL) before classroom attendance (Prober and Heath, 2012; Critz and Knight, 2013; Roehl et al., 2013; Bouwmeester et al., 2016; Shin and Brock, 2017; McLean and Attardi, 2018; Kraut et al., 2019). A keystone that promotes these pre-class activities is the systematic facilities provided by modern technologies (Strayer, 2012; Asef-Vazini, 2015; Bakr et al., 2016b; Boeve et al., 2017; Han and Klein, 2019). During classroom sessions, the students are encouraged to engage with more difficult comprehensive levels and deeper learning through case studies analysis and problem-solving exercises (Baeten et al., 2010; Strayer, 2012; Freeman et al., 2014; Hussey et al., 2014; Kim et al., 2014; Watson, 2015). One of the benefits of this student-driven learning is providing the teacher with ample time to recognize the knowledge gap of the students and their level of understanding (Moravec et al., 2010; Prober and Khan, 2013; Moraros et al., 2015; Chen et al., 2017; Roe et al., 2019). After the class, the students are asked to merge and integrate their knowledge through extra readings, completion of tasks, and peer-sharing discussion, providing them more flexibility with the deeper learning process (Abeysekera and Dawson, 2015; Hwang et al., 2015; Sharma et al., 2015; Ding et al., 2019). Several researchers have recorded the efficacy of the flipped classroom on students' performance and perceptions over the traditional lectures in multiple disciplines, such as anatomy and histology (Topping, 2014; Veeramani et al., 2015; Bakr et al., 2016a; Cheng et al., 2017; Morton and Colbert-Getz, 2017; Day, 2018; Fleagle et al., 2018), physiology (Tune et al., 2013; Street et al., 2015; Gopalan and Klann, 2017; Megaw and Zimanyi, 2019), biochemistry (Ojennus, 2016; Taylor et al., 2017; Williams et al., 2018), radiology (Belfli et al., 2015; O'Connor et al., 2016), and emergency medicine (Heitz et al., 2015; Lew, 2016; Kraut et al., 2019). Moreover, this educational methodology has been shown to improve learning outcomes in other nonmedical disciplines including dentistry (Park and Howell, 2015; Bakr et al., 2016a; Kellesarian, 2018), pharmacy (Pierce and Fox, 2012; McLaughlin et al., 2014; Koo et al., 2016; Kugler et al., 2019), nursing (Critz and Knight, 2013; Woodruff et al., 2014; Della Ratta, 2015; McCutcheon et al., 2015; Betihavas et al., 2016; Hanson, 2016), physics (Deslaureiers et al., 2011; Cagande and Jugar, 2018), engineering (Mason et al., 2013; Priyaadharshini and Sundaram, 2018; Castedo et al., 2019; Lo and Hew, 2019), and mathematics (Freeman et al., 2014; Grypp and Luebeck, 2015; Sun et al., 2018; Sun and Xie, 2020).

In Saudi Arabia, 40% of medical schools utilize traditional educational curricula. The other 60% have switched to more interactive, problem-based curricula (Omar, 2009; Yaqinuddin et al., 2016). The College of Medicine at Qassim University was the first in Saudi Arabia to introduce the problem-based learning (PBL) approach as its principal educational strategy since it was established in 2001 (Alamro and Schofield, 2012; Alamro, 2019). The PBL represents the core educational approach and covers the objectives of the modules, while the lectures, laboratories, and other educational activities are planned to facilitate students' understanding of the problems designed in the PBL sessions (Saqr and Alamro, 2019). The college program lasts for six years and is divided into three phases. The first phase, the preparatory year, is considered the premedical year. The second phase consists of the first, second, and third basic years, which comprise the integrated modular body systems. The third phase is clinical, comprising the fourth and fifth years. Each module in the first three basic years involves integration between multiple disciplines (gross anatomy, histology, embryology, physiology, biochemistry, pathology, pharmacology, health in the community, and clinical skills) (Alrebish et al., 2020). The module materials, including the anatomy topics, are delivered via multiple methods, such as large group lectures which outline the broad frame of the subject area. The laboratory sessions for cadaver dissection, prosection, and demonstration on the plastic and the plastinated specimens follow the lectures, allowing for more understanding and hands-on practical experience. The students practice active learning methods through PBL, team-based learning (TBL), seminars and panel discussion in small groups (Yaqinuddin et al., 2016). Variable methods are used for the assessment of students in the three basic years. The theoretical examination consists of integrated multidisciplinary questions in the form of multiple-choice questions (MCQs), modified essay questions (MEQs), and short-answer essay questions (SEQs). In addition, tutors evaluate the students' performance in the PBL sessions and seminar presentations. At the end of each module, an integrated, multidisciplinary, objective structured practical examination (OSPE) is held for practical evaluation (Saqr and Alamro, 2019).

The aim of the present study was to explore the effect of the flipped classroom on students' performance in anatomy and perceptions of their educational experience in the female section of the College of Medicine at Qassim University, Kingdom of Saudi Arabia. The flipped classroom is designed to give the teacher more time and opportunity to assist the students in applying, analyzing, and evaluating the anatomy materials. Therefore, the assessment of a higher level of cognition in Bloom's taxonomy (application and analysis) (Anderson et al., 2001) is recommended to evaluate the impact of the flipped classroom.

MATERIALS AND METHODS

Participants and Study Design

Participants were first-year students from the female section of the College of Medicine, Qassim University in the academic years 2017 to 2018 (n = 49) and 2018 to 2019 (n = 46) registered in an integrated module called the musculoskeletal system (MSK). The MSK module (11 weeks in both academic years) provided a broad spectrum of the anatomy of different regions (bones, muscles, and joints), which constituted a considerable proportion of the body structure and function. The gross anatomy discipline in this module was integrated with other disciplines such as histology, embryology, physiology, biochemistry, microbiology, pathology, pharmacology, and community and clinical skills. The MSK module materials were instructed as

follows: 31% large group lectures, 41% laboratory sessions, 20% PBL sessions, 3.3% TBL sessions, 1.7% seminar presentations, and 3% panel discussion. The anatomy materials in the MSK module consisted of 16 hours of large group lectures; all of them were delivered as traditional lectures in the academic year (2017–2018), while eight lectures were delivered as flipped classrooms in the following academic year (2018–2019), with 34 hours of laboratory sessions in both years. The experimental protocol was approved by the ethical research committee of the College of Medicine at Qassim University with a reference number QS 20180840.

A between-subjects design was planned to detect the difference between students' performance in the objectives of the 8 hours of the flipped and the traditional classrooms. Results of the 17 questions concerning the study objectives out of the 35 anatomy MCQs of the final summative examination of the MSK module, classified according to Bloom's taxonomy, were used as the principal study outcome to compare between the students' results of the flipped lectures of the academic year (2018–2019) and those of the traditional lectures of the academic year (2017–2018).

Flipped and Traditional Anatomy Classrooms

The anatomy objectives of the selected eight lectures (8 hours) delivered to all 46 students as a flipped classroom in the academic year (2018–2019) were the same as the eight traditional lectures (8 hours) delivered to all 49 students in the previous academic year (2017–2018). The traditional lectures consisted of an explanation of the objectives of each class, with some oral interactive teacher–students' questions in between the instruction. For the eight flipped classrooms, the anatomy materials of the pre-class activities were constructed as video tutorials. PowerPoint® Microsoft Office 365®, (Microsoft Corp., Redmond, WA) was used to create slides presentations with animations. Adobe Illustrator©, Creative Cloud (CC) software, (Adobe Systems Inc., San Jose, CA) and Adobe Photoshop©, CS software, (Adobe Systems Inc., San Jose, CA) were used to produce anatomy drawings and illustrations created by the anatomy faculty, and were added to their explanations in the PowerPoint presentations during the recorded video tutorials using "Record Slideshow." Twenty-eight video tutorials (with three to four assigned for pre-class activity before every lecture) were prepared, averaging 8 minutes in length, and covering the basic anatomical theoretical knowledge to prepare the students before coming to the class. Instructions about the learning objectives nominated pages in the required and essential anatomy textbooks, as well as educational web links of anatomy materials provided in the Saudi Digital Library (SDL; Ministry of Education, Riyadh, Kingdom of Saudi Arabia), to be visited and studied before each flipped class, were added to the video tutorials. These materials were uploaded on the Blackboard learning management system, version 9.1 (Blackboard Inc., Washington, DC), keeping in consideration a sufficient time for pre-class study, around 1 week before the class. In-class activities included large group discussions with an average of eight problem sets for each lecture. The class was designed to engage the students through teacher–student interaction and peer-tutoring to stimulate student interest, problem solving, and reasoning skills. A quiz was developed at the end of each class (posttest), covering the learning objectives in that period in the form of small group discussions to encourage every student to participate. The posttest questions included MCQs, fill in the text blank, and fill in the labeled blank illustrations incorporated in the video tutorials. Post-class activities included assigned online interactions with the teacher and peers in the form of open-ended questions in the discussion board on the Blackboard. All students were required to share in the discussion. Formative quizzes in the form of MCQs, matching, extended matching, and fill in the labeled blank illustrations were uploaded on the Blackboard to be solved in a requested time. Both the flipped and traditional classes had the same learning objectives, duration of classes, and other laboratory activities (cadaver dissection, prosections, plastic, and plastinated models demonstrations). Student orientation sessions about flipped classrooms were done before conducting the classes to prepare them for both pre-class study and in-class sharing activities as well as to clarify expected outcomes. An awareness session for the anatomy staff about the technique and possible benefits of the flipped classroom was done to prepare them for future implementation. Further orientation sessions were requested and conducted for faculty members of other departments of the college of medicine to share this active learning method.

Assessment Materials

All first-year students of both academic years finished the MSK system module final summative MCQs examinations (see Supporting Information file). All disciplines were assessed in 100 questions with 35 (35%) anatomy questions. The examinations were constructed with a blueprint which determined the accurate sampling of the content areas. The questions were constructed by each department sharing in the module, and then, revised by the module committee and organizer. Seventeen anatomy questions were postulated based on the same objectives of the traditional and flipped classrooms of both years and constructed by the same anatomy professor to ensure content validity evidence for the examinations (Cook and Beckman, 2006; Morton and Colbert-Getz, 2017). Item analysis was performed for both examinations for difficulty and discrimination, and no items were found with poor discrimination (less than 50% of students). Cohen's *d* test was determined by calculating the mean difference between the two groups of students, the first one taught through flipping the anatomy classrooms of the academic year (2018–2019), the second one taught through a traditional manner in the previous academic year (2017–2018), and then, dividing by the pooled standard deviation of the data (Cohen, 1992). It was applied to compare the strength of the relationship between the two groups regarding the students' age and their results in anatomy questions at the level of knowledge, applying, and analysis as well as their total scores in the final examinations of the MSK system module. These data were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) software, version 22 (IBM Corp., Armonk, NY). Results were considered significant when the *P*-value was less than 0.05.

Two different surveys were designed to collect students' and teachers' perceptions of the flipped classroom method as a new educational strategy. They consisted of five closed-ended questions using a five-point Likert scale (see Supporting Information files). The students and staff were asked to rank their feedback: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). The responses were measured as a percentage based on the numbers of students and teachers who selected a score of four and above.

vThe students were also requested to write narrative open-ended comments regarding the flipped classroom experience. The survey results were collected and reviewed. Cronbach's alpha test was used for all items of the students' and staff surveys to assess the internal consistency and reliability (Taber, 2018). The Kendall's tau B coefficient was used as a nonparametric measure of the strength and direction of association existing between two variables and to assess the validity of the surveys (Abdi, 2007). The average points on the Likert scale responses for each item were expressed as the mean ± standard deviation (±SD).

The qualitative, open-ended comments were analyzed by two independent investigators using open coding, then, categorized into key concept groups. Each comment was labeled as related to the following three themes: pre-class resources, in-class activities, and benefits of the flipped classroom (See Supporting Information file). Comments were classified as positive, negative, or bearing suggestions for improvement for each topic area. A final round of axial coding was implemented to confirm the collection of all important concepts. In order to determine the appropriateness of the data to proceed with factor analysis, reexamination of the validity of the students' and staff surveys was done through the Kaiser-Meyer-Olkin Measure (KMO) of sampling adequacy, which indicates the proportion of variance in variables that might be caused by underlying factors. Bartlett's test of sphericity was performed as an indicator of the strength of the relationship among variables (Chan and Idris, 2017).

RESULTS

Seventeen of one hundred MCQs of the final summative examinations covered the anatomy objectives of the flipped classrooms of the academic year (2018–2019) and those of the traditional lectures of the academic year (2017–2018). Two evaluators from the assessment unit in the College of Medicine at Qassim University classified these questions according to Bloom's taxonomy levels of cognition (recall, understand, apply, analyze, evaluate, create) (Adams, 2015). The "recall" and "understand" classes were combined into one class called "knowledge," which was rated as a "low" level of cognition. Eight anatomy MCQs were categorized in the knowledge class. The other nine questions were classified as a "high" level of cognition; five needed the students to "apply" and four to "analyze" the items.

Concerning the ages of the students, the mean and ± SD in the flipped classrooms group was 19.1 ± 0.4 and in the traditional classrooms was 19.1 ± 0.5. According to the independent *t* test, the mean difference in their ages was nonsignificant, 0.317 (*P*-value = 0.752). The mean and ± SD of the results of the final MSK module examinations was 68.1 ± 9.7 for the flipped classrooms group, and 69.4 ± 11.6 for the traditional group. The mean difference in the results of the final examinations was nonsignificant, 0.599 (*P*-value = 0.550).

Analysis of Students' Performance

Regarding the results of the anatomy questions at the levels of knowledge, application, and analysis, the mean and ±SD were 7.9 ± 1.5 (79.0 ± 15.0%), 3.1 ± 1.0 (77.5 ± 25.0%), and 2.0 ± 0.9 (66.7 ± 30.0%) for the flipped classrooms and were 7.3 ± 1.3 (73.0 ± 15.0%), 1.8 ± 1.0 (45.0 ± 25.0%), and 1.2 ± 0.8 (40.0 ± 26.7%) for the traditional classrooms, respectively. A significant mean difference was revealed concerning the results of the questions at the three levels: 2.118 (*P*-value = 0.037), 6.873 (*P*-value = 0.001), and 4.902 (*P*-value = 0.001), respectively. The mean difference in the age and final examination results of the students taught through flipped and traditional classrooms using Cohen's *d* test were 0.07 and 0.12, respectively. Concerning the students' grades on the anatomy questions, recorded during the assessment conducted during both types of classrooms at the level of knowledge, application, and analysis, they were 0.43, 1.41, and 1.01, respectively using Cohen's *d* test.

Analysis of Students' and Staff Perceptions

Regarding students' perceptions, 39 students (84.78%) completed the survey after the implementation of flipped classroom (Figs. 1 and 2). The Cronbach's alpha tests, used for all items of the students' and staff surveys, were 0.87 and 0.85, respectively. The correlation coefficient was found to range from 0.188 to 0.658 and from 0.142 to 0.758 for the students and staff surveys, respectively, indicating that the items in the survey were correlated well. Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy were 0.79 and 0.78, for the students and staff surveys, respectively. Bartlett's tests of sphericity were 0.001 and 0.46, for both students and staff surveys, respectively, which was considered significant. Regarding the students' survey, two factors were extracted from the questions by factor analysis, covering two main areas: "student preference" and "evaluation of the flipped classroom experience." The two factors explained 82.85% of the cumulative variance: 65.6% for factor 1 and 17.3% for factor 2. In addition, two factors were extracted from the questions in the staff survey by factor analysis, covering two main areas: "staff gain" and "attitude with education methods." The two factors explained 84.22% of the cumulative variance: 63.3% for factor 1 and 21.0% for factor 2.

Qualitative Analysis of Students Perceptions

The open-ended comments from the students' questionnaire were qualitatively analyzed and assigned into three themes:

Pre-class resources. Twenty-three percent (n = 8) of the students reported satisfaction with the uploaded educational materials before the class as they were clear, organized, and appropriate for adequate understanding. They found the recorded video tutorials very informative and convenient, providing them with sufficient preparation for the class. The students commented that the pre-class materials gave them the opportunity to learn freely at their own pace. Six percent (n = 2) of the students were worried about studying the materials individually before the class and suggested that it would have been more beneficial if they read and studied them in small groups as a peer-sharing environment.

In-class activities. Thirty-one percent (n = 11) of the students expressed their enthusiasm and interest in the in-class interaction. They reported that the open discussion of the problems clarified significant details and emphasized important anatomical facts. They claimed that active learning and peer-tutoring encouraged them to do more critical thinking, reasoning, and problem solving. They found the post-class quizzes very useful, as they provided an opportunity for self-evaluation and ensured the consolidation of their knowledge.

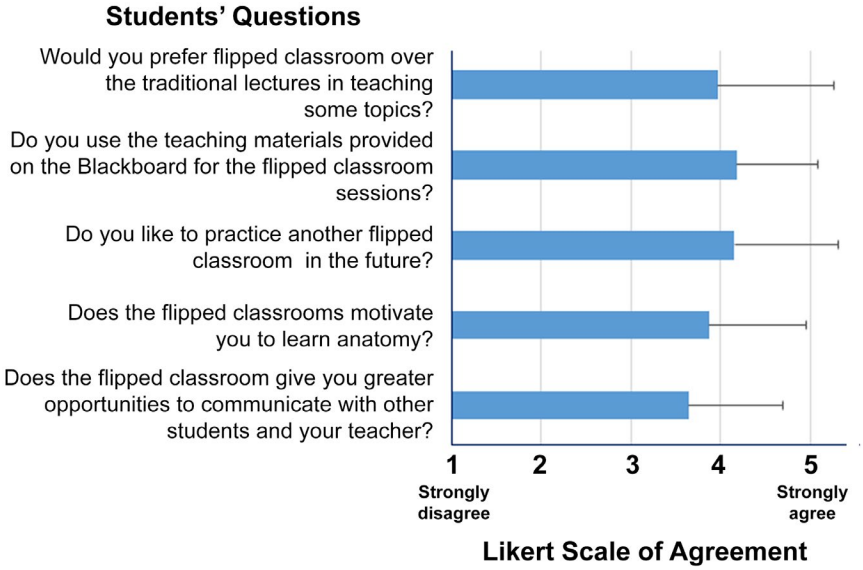

Figure 1.

Results of students' survey regarding their perceptions about flipped classroom experience. Scores are based on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) and expressed in means (±SD).

Benefits of flipped classroom. Forty percent (n = 14) of the students reported that the flipped classroom was a very interesting learning style, which made them more committed and attentive in the class and allowed them to be engaged in the learning-teaching process. It gave them the ability to achieve better understanding and analysis of the anatomy materials, with more opportunity for in and out of class active learning. They requested adoption of the flipped classroom in the educational activities of the other disciplines.

Examples of students' perceptions of the flipped classroom experience are listed in Table 1 and in the Supporting Information file.

DISCUSSION

Cohen's *d* test revealed a small effect size in comparing the mean difference of the age and final examination results of the students, as well as their grades in anatomy questions at the level of knowledge. This suggests that such differences were trivial, even if statistically significant. On the contrary, the students' results in anatomy questions at both application and analysis levels demonstrated a large effect size This finding suggests the remarkable impact of flipping the anatomy classrooms on improving the students' deeper levels of thinking according to Bloom's taxonomy. This finding was attributed

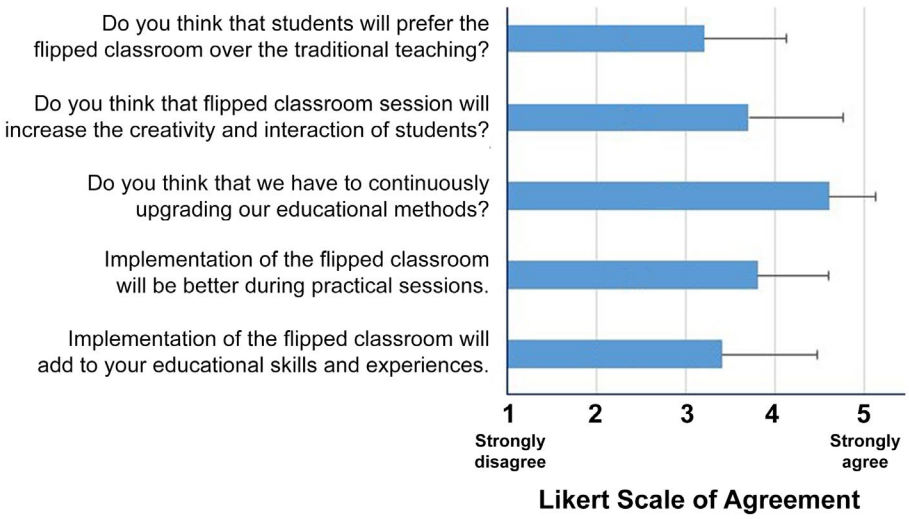

Figure 2.

Results of staff's survey regarding their perceptions about flipped classroom experience. Scores are based on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) and expressed in means (±SD).

Table 1.

Themes and Examples of Supporting Students' Quotes Regarding their Perceptions on Flipped Classroom Experience

Theme	Example of Student's Quote
Pre-class resources	• I found that uploading the educational materials, before the class, was accessible and beneficial. • I liked watching the educational videos and I could revise the uploaded materials any time on my pace. • I didn't like to read the materials independently before the class as I may misunderstand some points, so I prefer the traditional way.
In-class activities	• I was very interested in practicing the flipped classroom activities as they helped me to concentrate and to share these experiences with my colleagues. • I found the in-class discussion and interactions very useful. • I liked the post-class tests to discover my level of understanding.
Benefits of flipped classroom	• Studying needed less effort and time for better understanding and concentration during the class. • Flipped classroom gave me the chance for better achievement. • I prefer flipping of the class in all other disciplines.

to the effect of flipped classroom on students' learning process. It reflected higher levels of understanding, application, and analysis, which were significantly higher in flipped than in the traditional teaching group. Students' performance was enhanced through integration between self-studying of the pre-class uploaded materials and open discussion during the class. This outcome could be explained by the articulation between the cognitive domain, in the pre-class work, and psychomotor and attitude domains practiced in the class. The findings of the present study were consistent with the results of many authors who recorded that flipped classroom had great impact on the students' performance (Handelsman et al., 2004; Tune et al., 2013; Jensen et al., 2015; Stockwell et al., 2015; Street et al., 2015; Bakr et al., 2016a; Koo et al., 2016; Ryan and Reid, 2016; Gopalan and Klann, 2017; Dooley et al., 2018; Megaw and Zimanyi, 2019). Formative in-class assessments provided the students an immediate self-evaluation of their knowledge gaps (McLaughlin et al., 2014; Park and Howell, 2015). However, Chutinan et al. (2018) detected that flipped classroom promoted students' performance in a short-term evaluation, but did not affect their performance at the final summative examination. They suggested redesign of the new pedagogic strategy to be carefully implemented. Other researchers found no difference in students' performance in the flipped classroom study compared to the traditional lectures (Wong et al., 2014; Fautch, 2015; Moraros et al., 2015; Whillier and Lystad, 2015; Ojennus, 2016). Another study performed on flipping gross anatomy classrooms detected that the flipped classroom was more beneficial for lower performing students' knowledge gaining and relocation than for higher performing students (Day, 2018). Morton and Golbert-Getz (2017) attributed this difference to the Bloom's level of cognition. An assessment focusing only on the level of recall of information would mostly show no difference in performance between flipped and traditional classrooms, which was in agreement with the results of the present work. On the contrary, the flipped classroom was designed to increase the level of students' application and analysis which explained the improvement of the results of these questions in the flipped classroom group over the traditional group. Thus, this study emphasized the ability of the flipped classroom to increase the students' efficiency to solve problems at higher levels of Bloom's taxonomy. This finding was consistent with Shi et al. (2020) who reported that the flipped classroom would improve students' cognitive learning outcomes, especially with a collaborative environment that enhanced the pedagogic approaches.

The current work demonstrates multiple benefits of the flipped classroom for students, including the independent learning experience gained by digitalization of educational materials and the availability of multiple online educational resources. These materials represent a fast and economical way to enhance blended learning and provide an integration between teaching and technology which is in agreement with Belfli et al. (2015), Bakr et al. (2016a, b), Dooley et al. (2018), Shang and Liu (2018), and Hettiarachchi (2019). The students who participated in the perception survey were satisfied with the prerecorded video materials, as this pre-class activity provided them multiple chances to review the contents and restudy them, as was called "homework" before the flipped classroom (Herreid and Schiller, 2013). These materials allowed the students to learn calmly at their own pace without physical setting constrains and made the full use of the numerous components of the topics. Topping (2014) suggested that the anatomy videos were a very useful computer-aided instruction that might provide a compensation to the reduction of gross anatomy courses. However, some students complained of their fear of working independently and of the heavy pre-class workload, which were also reported by Missildine et al. (2013), Wong et al. (2014), and Kugler et al. (2019). This problem could be solved by reassuring and encouraging them to raise their accountability and sense of responsibility in the students' awareness sessions. In addition, recommendations should be highlighted for educators about the key challenges of the pre-class resources such as the students' study load, the length of the videos, the dedicated teachers for construction of the videos, and the time required for teachers to prepare them and required for the students to study them (Al-Zahrani, 2015; Bakr et al., 2016b; Al-Samarraie et al., 2019). The relatively high level of internal consistency of students and staff survey were based upon the Cronbach's alpha test. All correlation coefficients, utilizing the Kendall's tau B test on these surveys were positive, reflecting their validity and demonstrating that the items in the surveys

were correlated well. Determination of the appropriateness of the data obtained from student and staff surveys was needed to proceed with factor analysis. It was based upon the current results of KMO measure of sampling adequacy (more than 0.6) and the significance of Bartlett's test. These tests indicated that the sample size was large enough to assess the factor structure and the strong relationship among items of the surveys. One of the points highlighted in the survey was the benefit of the flipped classroom in providing the instructor a sufficient time for face-to-face interaction and in creating an optimal learning environment for student engagement after online preparation. Instructors reported that the flipped classroom could increase their teaching skills and experiences as well as students' creativity and interaction. This blending of traditional face-to-face in-class and pre-class online activities allowed an effective student-centered educational process. The flipped classroom also provided a self-directed learning experience that promoted long-life learning skills (Hagemeier and Mason, 2011; Belfli et al., 2015; Park and Howell, 2015). Another advantage of the flipped classroom was the observed in the positive attitude of students toward a variety of educational activities. This finding emphasized that the shift from passive traditional teaching to more active flipped learning promotes students' engagement, performance, and achievement (Jensen et al., 2015; Park and Kim, 2016; Ramnanan and Pound, 2017; Al-Samarraie et al., 2019; Megaw and Zimanyi, 2019). The students revealed their high satisfaction toward the flipped classroom modality, as they were interested in active learning, class interaction, critical thinking, and problem solving allowed by this educational strategy, which was in agreement with Pierce and Fox (2012), Critz and Knight (2013), McLaughlin et al. (2014), Hanson (2016), McLean and Attardi (2018), and Strelan et al. (2020). Al-Zahrani (2015) detected that flipped classroom significantly promoted students' creativity, especially with respect to fluency, flexibility, and novelty. However, regular monitoring of the learning goals and the action plan of students' achievements should be kept in consideration (Koo et al., 2016). The flipped classroom may help overcome the problems faced in the traditional classes of student hesitation lack of self-confidence, and little peer and teacher interaction. Entezari and Javdan (2016) reported that these negative behaviors affected the results of summative assessments, which could be one of the major causes of dropping out from the college. On the contrary, students who might lack self-confidence or prefer traditional education deserved specific attention as they needed further support to be familiar with the flipped class. Surprisingly, some of the anatomy staff postulated, in their perception survey, that students would not prefer the flipped classroom over the traditional teaching and were uncertain about students' response to the flipped classroom, which was contrary to the results of students' satisfaction survey. These teachers claimed that although traditional lectures could be boring, some additional strategies could be utilized to promote students' engagement and active participation as suggested by Pickering and Roberts (2018). Jambi et al. (2015) detected that staff development is a key challenge when designing a new educational modality. To overcome this challenge, further awareness sessions were scheduled for the anatomy staff, coping with their needs to upgrade their educational strategies and motivate them continuously, as recommended by Jambi et al. (2015). It is crucial to note that the flipped classroom might not fit for every teacher, course, or student (Strayer, 2012; Hussey et al., 2014). For example, employed students, especially with a full-time work, should have special considerations when choosing to educate them with flipped classroom (Christopher, 2018). In addition, the role of the educator is to select the topics that are appropriate to be read and studied by the student individually in the pre-class activities, and the ones that remain to be discussed in-class with the teacher. The present study reinforced the point that more passive and simple activities could be moved prior to the class, while difficult concepts could be delivered and practiced in tutorials during classroom activities with more active student engagement, which is the basis of the flipped classroom educational strategy.

Limitation of the Study

One of the limitations of the study was the low number of the anatomy staff participating in the survey, as well as the number of students expressing their reflections in their survey. Accordingly, regression analysis for the relationship between the weighted factor scores of the students and their examination scores could not be applied due to incomplete contributions from the students in the surveys. Another limitation was the low number of questions in the surveys that involved the principal component analysis. Finally, staff resistance to the new teaching method of the flipped classroom and their preference for the traditional lectures was considered a limitation of the study, which could be overcome by multiple awareness sessions about the potential benefits and outcomes of a flipped classroom.

CONCLUSIONS

This study adds to the literature that investigates the impact of a flipped classroom. It emphasizes its influence on Qassim medical students' performance, specifically in the gross anatomy classrooms. In order to graduate efficient health-care providers, advanced assessment of performance should be delivered. This type of assessment would ensure skills in answering different cognitive test levels, which could be provided by the flipped classroom modality. The findings of the present study clarify the benefits of the flipped classroom, particularly when the assessment requires application or analysis. The surveys revealed that most of the students were interested in the pre-class activities, which facilitated their engagement and concentration during the class. However, further studies are required to determine the best practices of flipped classroom that could meet the learning needs of the students and provide them a pleasurable learning experience.

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