Title: A Multiyear Comparative Study on Flipping a Dental Hygiene Course

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ABSTRACT

INTRODUCTION

The flipped classroom model changes the learning dynamic from an instructor-centered design to a student-centered design whereby the student has more opportunities for practice with guidance and feedback from the instructor. The present study is an investigation on the impact of employing the features of a flipped educational model compared with a traditional model on student course grades across several years.

LITERATURE REVIEW

Few studies investigated the impact of the model on courses in dental hygiene covering the topic of clinical applications and psychomotor skill development.

BACKGROUND

In 2014, faculty from New York University Dentistry, initiated a redesign to the Principles of Dental Hygiene I pre-clinic course to improve student learning as well as the administration of the course. The redesign process was completed in 2016 for implementation in 2017.

METHODS

We compared outcomes on performance measures (e.g., grades for quizzes, exams, and competencies) as well as overall course grades for students who engaged in a traditional model of the course to students who engaged in a flipped model of the course.

RESULTS

This study provides aggregated results comparing the traditional year (2014) to flipped years (2017-2019) as well as individual pairwise comparisons. Descriptive statistics revealed higher averages on most performance measures and course grades for students in the flipped model over consecutive years (2017-2019) compared to the 2014 traditional model. T-test results comparing the traditional baseline to aggregate flipped years showed statistical significance for overall Course Grade and near transfer tests (Quizzes and Instrumentation Competencies) but not far transfer tests (Instrumentation Assessments and Final Exams). Analysis of Variance (ANOVA) on Course Grade yielded significant variation among individual flipped versus the traditional year, $F(3, 250) = 5.43$, $p=.001$. Post hoc Tukey pairwise tests showed statistically significant course grade averages for individual flipped years 2017 and 2019 compared to 2014 but not for 2018 compared to 2014. Post hoc Tukey pairwise test showed mixed results for specific performance measures aimed at assessing types of learning such as cognitive and psychomotor skills.

CONCLUSION

The flipped method showed higher outcomes overall compared to the traditional method.

LIMITATIONS AND FUTURE RESEARCH

To overcome limitations we compared results over consecutive years and will continue to monitor the outcomes to confirm these results. Future studies will aim to test new teaching and learning strategies on the specific performance measures aimed at types of learning in order to increase averages and provide more stable results.

INTRODUCTION

Instructors seeking to change their teaching approach from the traditional lecture format to a more cognitively active format can leverage a flipped classroom approach, and employ active learning strategies that are facilitated by media and technology (Milman, 2012). By definition, the flipped class approach is any method of delivering pre-class instructional content guided by lower level learning objectives, so that the in-class time can focus on student-centered, higher order learning objectives and activities with guidance from the instructor (Lage et al., 2000; Anderson et al., 2001; Makice, 2012)

Negative learning outcomes, such as cognitive overload through over engagement, may occur when the pre-class materials are poorly designed or when the materials are not aligned with the learning objectives (Clark and Mayer, 2016). If pre-class work instructional materials and resources are paired with formative assessments, meaningful feedback may be either immediate or delayed, both of which may impact learning differently. In-class activities that support learning objectives may use technology and can include case based methods, simulations, question-driven methods, student driven presentations, and collaborative learning exercises. Successful implementation of an in-class active learning strategy may deem a challenge to instructors not experienced with the new strategy and training may be required. All of these factors contribute to the success and failure of the flipped model. It is therefore good instructional design practice to conduct iterative analysis to assess whether the revised course design enhanced or diminished learning and requires additional revisions to make the new design model successful. Success may be defined by improved student learning, as evidenced by course grades and course administration.

This study is an investigation on the impact of employing features of a flipped educational model with a traditional model on student course grades over time. Specific performance measures aimed at assessing types of learning such as cognitive and psychomotor skills were compared. The redesign of the course sought to better prepare students for pre-clinic with pre-class interactive modules, activities, and low-stake assessments, thereby freeing up in-class guided practice time and the need for redundant in-class demonstrations.

LITERATURE REVIEW

A review of the literature focusing specifically on topics in dentistry such as fixed prosthodontics (Nishigawa et al., 2017), pediatric dentistry (Bohaty et al., 2016), anatomy and tooth morphology (Bakr et al., 2016; Chutinan et al., 2018), and periodontal diagnosis and treatment planning (Lee & Kim, 2018), shows predominantly favorable results for the flipped class model albeit some design limitations. It is not always clear which feature of the flipped model influenced positive results in some of the successful cases. A few research cases covering topics in dental materials (Joshi et al., 2018), and dental ergonomics (Islam et al., 2018), did not find statistical significance between flipped model designs and traditional formats. Reasons for not finding a greater impact may be due to the type of content or skill to be learned, lack of faculty readiness, quality of materials, lack of prior knowledge control measures, the timing of students accessing pre-class work materials prior to attending the live active class, or other unknown factors.

Successful design and use of the flipped model may depend on the type of learning and proximity of learning to practice (Bohaty et al., 2016). If the type of content to be learned is mainly cognitive in nature as described in this study then the proximity of pre-class work material to the in-class activities may not interfere with learning. But if the course included other types of learning, such as psychomotor skills in a laboratory setting, the results may be different (Islam et al., 2018). If using video to demonstrate psychomotor skills and procedures is not followed by immediate practice and feedback the learning experience remains inert. Any delay in psychomotor practice may introduce a decline in memory retention of the instructional skill. Waiting until class time to practice for the first time may be too late in terms of accurate recall of psychomotor skills and procedural steps. A timing gap forms between watching the demonstration and practicing the skill. Proximity of cognitive skills to practicing psychomotor skills in a clinical laboratory setting appears to matter and should be investigated further. In a similar vein, when the instructional material or topic is complicated by providing a video for students to process before class may hinder learning (Islam et al., 2018). The flipped model advocates introducing foundational concepts and

learning activities that fall lower in Bloom's Taxonomy in the pre-class work and deeper learning for in-class (Milman, 2012; Anderson et al., 2001).

Another design feature to consider is the timing of the assessments; immediate versus delayed. While the Bakr et al. (2016) study found positive results on delayed assessments in their dental anatomy course, Chutinan et al. (2018) found positive statistically significant results on some immediate assessments but not on delayed assessments (e.g., final exam) in their dental anatomy course. Chutinan et al. (2018) concede that the delayed assessment, namely the final exam, covered content over and beyond that of anatomy and thus may not be an appropriate measure.

It is usually good educational practice to include practice or formative assessments with the pre-class instructional materials. This allows the students to assess their understanding of the material and come to class with questions. The decision to not include formative assessments in the pre-class work show mixed results on the impact of learning (Lee & Kim, 2018; Joshi et al., 2018). In some cases, excluding formative assessments in the pre-work still provided positive results favoring the flipped model (Lee & Kim, 2018). In other cases, the exclusion may have impacted results that did not amount to statistical significance (Joshi et al., 2018). Attribution to the reasons for these results warrants further investigation.

Often the flipped model is compared to traditional in-class lecture or demonstration formats. Only one study evaluated the flipped model to another teaching and learning approach, namely team-based learning (Nishigawa et al., 2017). While average scores were slightly higher for students in the team-based approach, the authors of this study found no statistically significant differences in student outcomes between these two approaches (Nishigawa et al., 2017). Students in the flipped approach spent more time before class preparing than the team-based class. But the active learning strategy for the flipped approach was not as active in the classroom as the comparable team-based method. Further investigation of the flipped model should be tested using more active learning strategies.

While the literature demonstrates some variation in success for the flipped class used across different dental topics with various designs applied, the outcomes were overall positive. Few studies investigated the impact of the model on courses in dental hygiene and warrants continued research. There is also a gap in the literature covering the topic of clinical applications and psychomotor skill development in dental hygiene. Based on the literature it appears that the success of the flipped model depends on how thoughtful design takes into consideration the types of learning (e.g., cognitive, psychomotor skills), the proximity of learning between the instructional content and practice, and the types of activities to support learning in pre-class work materials and in-class.

BACKGROUND

Principles of Dental Hygiene I Clinic is an introductory course designed to integrate scientific knowledge and critical thinking skills while delivering comprehensive care necessary for the prevention of diseases of the teeth and surrounding tissue. The course provides the foundational knowledge for all clinical applications that are used in dental hygiene patient care. Principles of Dental Hygiene I Clinic introduces foundational material, which is built upon in clinical experiences during subsequent semesters. It establishes goals which students need to work towards and utilize in a clinical setting. Topics covered in this course include: prevention of transmissible disease and cross contamination in a dental office; assessment skills that include the taking of a comprehensive health history, measurement of vital signs, head and neck examination, oral hard and soft tissue charting, and gingival description; instrumentation skills that employ correct ergonomics, topical anesthesia, instrument sharpening, an appropriate grasp and finger rest, use of the mouth mirror; and several oral health interventions that include fluoride therapy (tray and varnish), use of indices (Sulcular Bleeding Index, Gingival Index, Plaque Control Record), and of course patient oral hygiene instructions.

This course is currently taken by freshman Dental Hygiene students and has approximately 60-70 students each year. Over a period of 14 weeks, students must not only be able to demonstrate learned skills, but also use critical thinking to provide acceptable patient outcomes that span the entire dental hygiene process of care. Manual skills are developed through weekly pre-clinical experiences on

typodonts (teeth models) and student partners. Gaps in knowledge must be addressed promptly, since dental hygiene students are presented with a new task each week prior to practice and demonstration of competency in a pre-clinical setting. The accelerated need to process information places a demand on students to perform, regardless of their capability or learning style preferences.

There were many challenges faced in the traditional design of the Principles of Dental Hygiene I Clinic course. Introduction of a new skill required in-class demonstrations and took away student practice time; not having enough practice time was a constant student complaint in the course evaluations each year. In addition, the demonstrations were often difficult to be viewed by the entire class. The students needed close up views, enhanced views, and ability to pause, skip and repeat the demonstration. Due to the large class size, but small physical lab size, the students in a cohort had to be broken up into three day groups and one evening group. Repeated demonstrations were needed throughout the week. Even if given by the same instructor, there was no guarantee the exact same information was delivered to all groups. It left room for human error. There was a need to ensure the delivery of standardized step-by-step instruction would be given to various student groups. Although students were assigned readings from textbooks and handouts to complete prior to class, students often came to class unprepared, causing much class time spent on very basic information that could have been acquired by the student prior to class. This resulted in less time for coverage of more difficult concepts and practice. The students needed the motivation and ability to be active in their own process of learning. Given these challenges, the design of the course needed to change. To address the change, a flipped model shaped the new design.

It took two years (2015 and 2016) to complete the flipped model redesign, during which, completed modules were implemented as they were completed. The 2014 cohort was the last class to receive the traditional course and the 2017 cohort was the first class to receive the complete redesigned course. The same faculty member taught the 2014 traditional course as well as the 2017 and 2018 flipped course while a new faculty member taught the 2019 flipped course. To evaluate the impact of the change an internal research team performed the statistical analysis and results thus reducing potential biases.

METHODS

The Formal Internal Review Board ((IRB-FY2019-2886) at New York University approved this study and deemed it exempt.

Study design

A longitudinal design was used for this project. At New York University Dentistry students participated in this project during regular scheduled instructional class time for the Principles of Dental Hygiene Level I course. Two sections of the course participated in the study across several years (2014, 2017, 2018, and 2019). Using normal enrollment processes, students self-enrolled into either section of the course.

Participants

Table 1 displays the sample size based on the total number of students in each year. Two hundred and fifty-four students totaled across four years. Across all four years the number of registered students had similar enrollment with an average of 63.5 students.

Table 1: *Participants*

Year	Semester	Type	Total
2014	*Fall*	*Traditional*	69
2017	*Fall*	*Flipped*	67
2018	*Fall*	*Flipped*	64
2019	*Fall*	*Flipped*	54
Total N			254

Study Procedures, Measures, and Materials

A typical course offering, traditional or flipped, consists of 14 weeks. Both sections across all years evaluated in this study completed the same quizzes, competency evaluations, and examinations. The intervention aimed to assess and analyze the impact of this new model on the outcomes based on the grade distribution as well as the specific measures focused on either cognitive or psychomotor skills. The course grade distribution remained the same between 2014, 2017, 2018, and 2019. Course grade is a weighted sum of Quizzes (10%), Assessment Competencies (25%), Instrumentation Competencies (35%), Final Instrumentation Examinations (30%). The quizzes focused on the assessment of cognitive skills. Assessment competencies contained a combination of cognitive, critical thinking, and psychomotor skills. Instrumentation competencies assessed student psychomotor skills with instruments. And final exams focused on the assessment of psychomotor skills.

The only difference between the courses was the model, traditional versus flipped (see Table 2). In the traditional course design students prepared for class by reading assigned textbook pages and reviewing handouts. In-class time focused on demonstration and delivering cognitive skills with some remaining time for practice. Students in the flipped version accessed online materials in the form of video demonstrations, cognitive text and images, and knowledge check activities prior to attending weekly in-class sessions. The pre-class work material delivered the demonstrations and cognitive skills allowing for an increase in guided practice time in-class. Beyond those differences, all other features of the course designs remained the same whereby the students completed the same 12 weekly quizzes, 16 weekly Competency Assessments (5 Assessment Competencies + 11 Instrumentation Competencies), and 1 end of semester Final Exam (5 Final Instrumentation Exams). Class time did not decrease in either course design approach.

Table 2: *Course Design Feature Comparison*

Traditional Course Design (2014)	Flipped Course Design (2017 – 2019)
Pre-Class Work: Text-book Reading & Handouts (Weekly)	*Pre-Class Work: Multi-media Online Lessons with Interactive Videos, Text & Graphics, Handouts & Knowledge Check Activities. Textbook Readings (Weekly)*
Full In-Class Demonstrations (Average 30 min. Weekly)	*No In-Class Demonstrations, Gain in Practice Time (Average 30 min. Weekly)*
1 Four Hour In-Class Meeting (Weekly)	*1 Four Hour In-Class Meeting (Weekly)*
1 Two Hour SIM Lab (Weekly)	*1 Two Hour SIM Lab (Weekly)*

1 Two Hour In-Class Meeting (Weekly)	*1 Two Hour In-Class Meeting (Weekly)*
Scheduled Online Pre-Class Quiz (12 total) 10% of Final Grade	*Scheduled Online Pre-Class Quiz (12 total) 10% of Final Grade*
5 Assessment and 11 Instrumentation Competency Exams (16 total delivered 1-2 times per week) 60% of Final Grade	*5 Assessment and 11 Instrumentation Competency Exams (16 total delivered 1-2 times per week) 60% of Final Grade*
1 Final Exam (5 Final Instrumentation Exams) (End of Semester) 30% of Final Grade	*1 Final Exam (5 Final Instrumentation Exams) (End of Semester) 30% of Final Grade*

To compare differences between the two sections we performed Analysis of Variance (ANOVA) and post hoc Tukey pairwise tests on all performance measures including overall course scores.

RESULTS

Figures 1, 2, and 3 show box plot graphs of average course grade scores for each condition, traditional and flipped, for each year. For each year, the flipped shows a higher average score level compared to the traditional condition. Figures 4, 5, 6, and 7 show box plot graphs of average scores for each condition, traditional and flipped, for each type of test. Figure 6 shows the greatest difference between flipped and traditional based on instrumentation competencies. Figures 4, 5, and 7 show very small differences between flipped and traditional based on the type of grading activity.

Figure 1

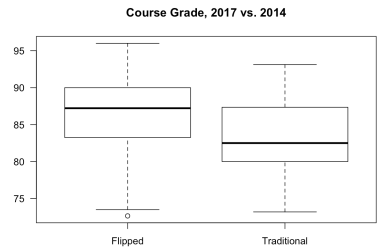


Figure 2

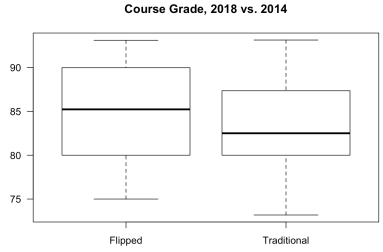


Figure 3

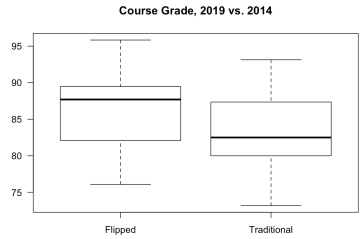


Figure 4

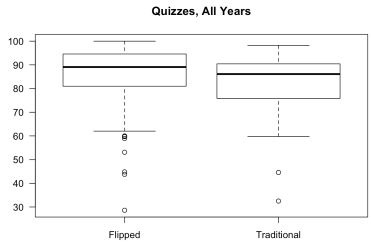


Figure 5

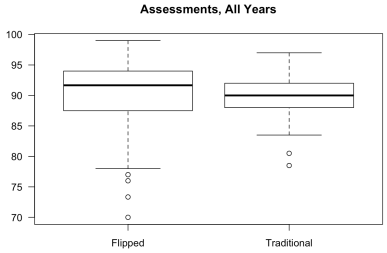


Figure 6

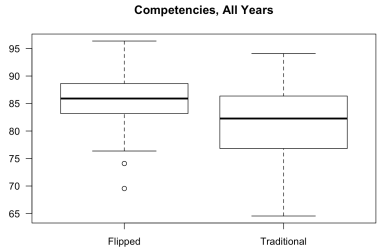
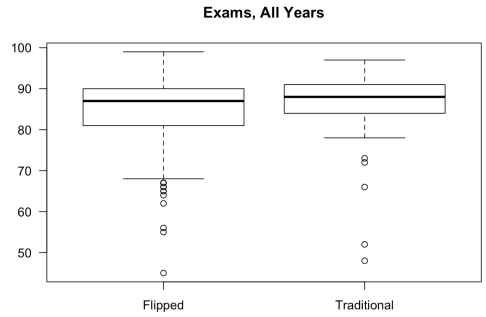


Figure 7



Descriptive statistics including mean (M) and standard deviations (SD) show similarities and differences between the two conditions based on performance measures between the traditional baseline and each flipped year (Table 3). All students participating in the Principles of Dental Hygiene Level I course, (N=254), there was an increase in averages from 2014 to 2017, 2014 to 2018, and 2014 to 2019 for quizzes, assessments, and instrumentation competencies. The only measurement that revealed a decrease in averages was final exams. Final exams observed higher means in 2014 (M=86.1) compared to 2017 (M=84.0), 2018 (M=83.2), and 2019 (M=83.9). The results showed higher course grade averages for students in the flipped model in consecutive years 2017, (M=86.16, SD=5.1), 2018, (M=84.87, SD=5.4), and 2019 (M= 86.3, SD = 4.8) compared to the traditional model (2014), (M=83.10, SD=5.2).

Table 3. *Descriptive Statistics of Overall Performance by Year*

	Traditional 2014 (*n= 69*)	Flipped 2017 (*n= 67*)	Flipped 2018 (*n= 64*)	Flipped 2019 (*n= 54*)
Measure	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Quizzes	82.3 (12.5)	85.0 (10.2)	89.4 (11.1)	84.1 (13.2)
Assessments	89.8 (3.5)	91.1 (5.0)	90.4 (5.4)	90.2 (5.2)
Instrumentation	81.2 (6.5)	85.3 (4.5)	85.9 (3.7)	86.2 (4.1)
Final Exams	86.1 (8.3)	84.0 (10.0)	83.2 (8.5)	83.9 (9.3)
Course grade	83.10 (5.16)	86.16 (5.1)	84.87 (5.4)	86.3 (4.8)

Descriptive statistics including mean (M), standard deviations (SD), and t-test differences show similarities and differences between the two conditions based on performance measures between the traditional baseline and the aggregate of all flipped years (Table 4). Quizzes, Instrumentation Competencies, and Course grade showed statistical significance favoring the aggregated flipped years compared to the traditional baseline. Final Exams showed statistical significance favoring the traditional year compared to the aggregate of flipped years. Despite higher average scores for the aggregate of flipped years compared to the traditional baseline, Instrumentation Assessments did not show statistical significance.

Table 4. *Descriptive Statistics & t-Tests of Overall Performance Traditional versus Flipped*

	Traditional 2014 (*n= 69*)	Flipped 2017 - 2019 (*n= 185*)	t-test	
Measure	*Mean (SD)*	*Mean (SD)*	*t-test value*	*p-value*

Quizzes	82.3 (12.5)	86.2 (11.6)	2.29	0.024
Assessments	89.8 (3.5)	90.6 (5.2)	1.48	0.14
Instrumentation	81.2 (6.5)	85.8 (4.1)	5.49	0
Final Exams	86.1 (8.3)	83.7 (9.3)	-1.98	0.05
Course grade	83.10 (5.16)	85.75 (5.1)	3.64	0

Figure 8 shows correlations based on mean scores between based on assessment types and grades. Table 5 provides correlation values based on mean scores between assessments types and grades. The strongest correlation is between instrumentation competency scores and course grade (r=0.64) as well as final exams and course grades (r=0.64). The weakest correlation is between final exams and quizzes (r=0.03).

Figure 8

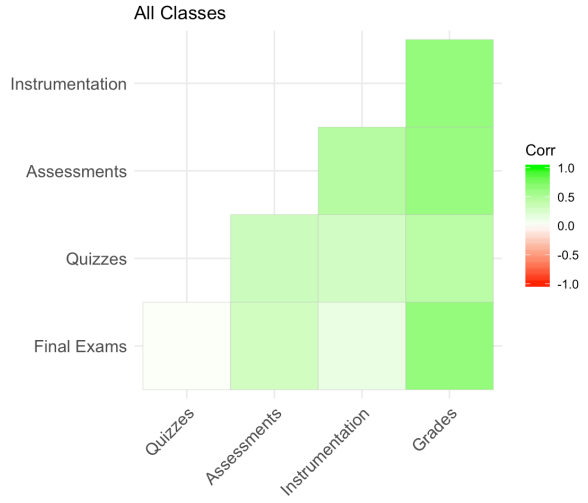


Table 5. *Correlations all years*

x/y	Assessment Score	Quiz Score	Instrumentation	Final Exams	Course Grade
Assessments	1	0.33	0.45	0.3	0.61
Quizzes	0.33	1	0.29	0.03	0.43
Instrumentation	0.45	0.29	1	0.13	0.64
Final Exams	0.3	0.03	0.13	1	0.64
Course grade	0.61	0.43	0.64	0.64	1

An analysis of variance (ANOVA) (Table 6) and Post hoc Tukey tests (Table 7) on scores for each performance measure yielded mixed results based on the type of assessment and overall course grade. ANOVA on Course Grade yielded significant variation among flipped versus traditional years, F (3, 250) = 5.43, p=.001. A post hoc Tukey test showed Course Grades were statistically significantly different between traditional (2014) and flipped (2017) and between traditional (2014) and flipped (2019). Despite increased course grade averages for the 2018 flipped course compared to the 2014 traditional course (1.77 mean point difference), the difference was not statistically significant.

Table 6. *ANOVA Traditional (2014), Flipped (2017 - 2019)*

Measure	Variable	df	Type 1 Sum of Squares	Mean Square	F	p-value	Partial Eta Squared
Quizzes	Year Residuals	3 250	1781.601 34468.572	593.867 137.874	4.307	**0.006***	0.052
Assessments	Year Residuals	3 250	65.744 5771.044	21.915 23.084	0.949	0.417	0.011
Instrumentation	Year Residuals	3 250	1101.676 5970.999	367.225 23.884	15.375	**0***	0.185
Final Exams	Year Residuals	3 250	315.757 20489.125	105.252 81.956	1.284	0.28	0.015
Course Grade	Year Residuals	3 250	427.506 6561.45	142.502 26.246	5.43	**0.001***	0.065

*The mean difference is significant at the .05 level

Table 7. *Post Hoc Tukey HSD Pairwise Comparison of Performances by Year (Traditional versus Flipped)*

	Trad. 2014 / Flip. 2017	Trad. 2014 / Flip. 2018	Trad.2014 / Flip. 2019	Flip. 2017 / Flip. 2018	Flip.2017 / Flip.2019	Flip. 2017 / Flip. 2019
Measure	Mean Diff., Adjusted p	Mean Diff., Adjusted p	Mean Diff., Adjusted p	Mean Diff., Adjusted p	Mean Diff., Adjusted p	Mean Diff., Adjusted p
Quizzes	2.69, 0.541	7.11, 0.003*	1.811, 0.831	4.42, 0.139	-0.879, 0.977	-0.879, 0.977
Assessments	1.359, 0.353	0.677, 0.849	0.406, 0.967	-0.682, 0.849	-0.953, 0.699	-0.953, 0.699
Instrumentation	4.119, 0*	4.771, 0*	5.063, 0*	0.653, 0.871	0.944, 0.716	0.944, 0.716
Final Exams	-2.087, 0.536	-2.915, 0.25	-2.18, 0.548	-0.828, 0.953	-0.093, 1	-0.093, 1
Course grade	3.058, 0.003*	1.766, 0.196	3.174, 0.004*	-1.292, 0.474	0.116, 0.999	0.116, 0.999

*The mean difference is significant at the .05 level

In terms of the specific measurements that assessed types of learning (e.g., cognitive and/or psychomotor skills) the results are mixed between traditional versus flipped years. For the Quizzes focusing on cognitive skills, an analysis of variance (ANOVA) on scores yielded significant variation among years, F (3, 250) = 4.307, p =.006. While quiz averages were higher for all flipped years compared to the traditional year, a post hoc Tukey test showed quiz results from traditional (2014) were not statistically significantly different from flipped (2017) nor (2019) quiz results but traditional (2014) quiz results were statistically significantly different from flipped (2018) results. ANOVA on Assessment Competencies focusing on a combination of cognitive and psychomotor skills were not statistically significantly different between years, F (3, 250) = 0.949, p=.417. ANOVA on Instrumentation Competencies focusing on psychomotor skills showed statistically significant results, F (3, 250) = 15.375, p=0. A post hoc Tukey test showed the Instrumentation Competencies were statistically significantly different between 2014 and 2017 scores as well as 2014 and 2018 and 2014 and 2019. The impact of the flipped model on instrumentation competencies assessing psychomotor skills appears strong. But, ANOVA results on Final Exam scores focusing on psychomotor skills was not statistically significantly different between traditional versus flipped years, F (3,250) = 1.284, p=0.28.

Table 7 also shows the comparative results between flipped years to demonstrate simply to demonstrate no statistically significant differences between years based on the assessment type or course grade.

CONCLUSIONS

In this study showed the comparison between the traditional baseline and the aggregate of flipped years as well as the individual flipped years. At the aggregate level, results of this study showed improved learning on averages of most performance measures as well as overall course grades favoring the flipped class model approach across consecutive years. The flipped model was associated with significant improvements in the competencies and the quizzes while also seeing decreases in the scores on the final exam. However, the magnitude of the effects plus the weighting of the assignments (10% quizzes + 60% competency evaluations versus 30% final exam) led to improvements in the course grade. The flipped model appears to have helped more with frequent weekly assessments while possibly not preparing the class for the less frequent assessments and the cumulative final exam. This provides an opportunity to change the design of the course to include more cumulative reviews throughout the course to help prepare for the less frequent types of tests. This idea should be tested in the future.

At the level of individual years, despite strong results for year 2017 and 2019, the results are mixed at the course grade level for year 2018 as well as on performance measures focusing on knowledge of content or psychomotor skills. These findings may question the impact of isolated skills within the flipped model to consistently improve learning at a level of statistical significance. Other variables may be impacting the results to demonstrate more stable results. But these mixed findings do not change the overall benefit of the model to provide a more effective teaching and learning environment. Mixed findings inspire making small changes to the model and continual improvements supported by research findings.

To address concerns that a flipped model may take up too much student time and increase stress, in this case, the addition of technology enhanced pre-class learning does not appear to add undue burden to students learning. In addition, a survey of the faculty expressed students coming to class more prepared and had improved quality questions. The video demonstrations alleviated the need for faculty to provide the demonstrations themselves and allowed faculty to have a reliable reference to direct students to when needed. The videos also supported standardization among faculty when providing feedback to the students, since these demonstrations were considered the “gold standard” in the techniques covered.

LIMITATIONS AND FUTURE RESEARCH

This study was conducted in a live course across several years. Confounding and unforeseen variables may be the culprit to providing more stable results. Lack of control for prior knowledge or baseline measures between cohorts may be an issue but given the level of education and experience in dental hygiene baseline measures are close to impossible to acquire. To overcome some limitations, we compared results over consecutive years and will continue to monitor the outcomes to confirm these results. Future studies will aim to test new teaching and learning strategies on the specific performance measures aimed at types of learning in order to continue to increase averages as well as target specific skills.

Continued and additional research should be conducted in dentistry to determine for which types of learning and cohorts the flipped model can successfully be applied. Isolating features such as active learning strategies used in various flipped format designs should be assessed to continue improving specifics to the model, student outcomes, and ease for faculty to administer. The collective body of research will continue to explain the feasibility and success of the flipped classroom in dental education.

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