The Impact of a Flipped Classroom Compared to Lecture-Based Teaching on Achieving Course Outcomes

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Abstract

Education is one of the most vital components that compose a modern society and as such, its improvement and optimization is always sought. This study investigates the efficacy between two learning methods in a graduate level biochemistry course: complete active learning and a hybrid of active and passive learning. Active learning is one method of achieving course outcomes with an emphasis on student responsibility through self-studying of course material followed by classroom discussion. In comparison, passive learning emphasizes instructor responsibility through didactic lecturing of course material. The aftermath results following a hybrid form of active and passive learning (in-class didactic lecture and team-based learning) versus complete active learning (self-studying course material before class, classroom discussion, and team-based learning) will be compared among four cohorts of biochemistry students. A survey will be sent out seeking to gather qualitative and quantitative data that may later contribute to the confounding of main objective results. Descriptive statistics analyses will sort, organize, and filter survey responses in order to examine whether or not differences there affected the objective. Main objective results will rely on exam and readiness assessment test (RAT) scores from all four cohorts of students. Various biochemistry topics will be compared per these scores. An independent t-test, one-way ANOVA, two-way ANOVA, and ANCOVA test will be used to assess all the data. Within some of these statistical tests, survey responses will be accounted, assessed, and controlled so as not to convolute findings. These factors include: continuous independent variables (Example: age), nominal variables (Example: undergraduate status), and covariates (Example: GPA). The hypothesis of this study is that there will be a statistically significant difference between the cohorts that use a hybrid of active and passive learning and the cohorts that use complete active learning.

Statement of the Research Problem

Background of the Flipped Classroom Approach

Education is a vast industry that requires the effort of both students and teachers. The question as to the most effective method of teaching and learning, however, remains to be seen. Conventional classroom settings consist of a didactic method of teaching involving passive learning on the part of the students. This leaves little room for class participation (16). In recent years, a newer style of teaching and learning has emerged known as active learning; this dynamic method commonly utilizes a team-based approach in order for students to achieve course objectives. The flipped classroom is one form of active learning, which involves student preparation prior to class followed by assessments and application exercises (9). Because didactic pedagogy has been the conventional method, the diametric change in classroom style seems to be a cumbersome feat; this begs the question of why it is being attempted. As the times change, however, so do the students. The millennial generation of students is more inclined to work in teams and learn in settings that promote doing over listening (10). Furthermore, students' reactions to the flipped classroom model have been positive in conjunction with greater performance on the part of the students, although initially students are resistant to change and skeptical of its efficacy (4,17).

Another form of active learning that will be investigated is team-based learning (TBL), most noticeably seen in graduate healthcare learning institutions. The terms flipped classroom and TBL are in some cases used synonymously because flipped classroom is usually manifested as TBL (4). TBL and the flipped classroom setting are "active learning [strategies] that [build] on individuals' strengths by allowing them to collaborate and work as a team to achieve a common learning objective" (7). These learning objectives are generally assessed by student examination results.

The gap in research that is addressed by this project is the impact that active learning with team-based learning will have on basic science classes such as medicinal biochemistry. It is still assumed that flipped classroom cannot be used to teach graduate science classes and this project seeks to prove otherwise.

Operational Definitions

The study involves various operational definitions that are unique to pedagogy. Among them are active learning, passive learning, flipped classroom, preparatory quizzes, collaborative discussion, lecture-based learning (LBL), individual readiness assurance test (iRAT) and team readiness assurance test (tRAT), and application exercises.

Passive learning does not require active participation on the part of the students (16). Instead, the instructor is required to present the material to the students didactically. Lecture-based learning (LBL) is a passive learning method and is the traditional method used by many schools and higher education where the students are required to learn based on lectures given by the instructor during class time (3). In this format, the students are encouraged to ask questions of the instructor in order to gain knowledge or clarify concepts.

Active learning requires that students participate in class discussion in order to learn (11). In active learning, the students are required to prepare before class by reading assigned materials. The instructor gauges the knowledge of the students by asking questions, often allowing the students to respond via polls in order to clarify material. Additionally, TBL is an active learning method that consists of students being placed into groups where they work together on group assessments of class material. Within TBL there are iRATs and tRATs followed by application assessments. The tRATs are taken immediately following the iRATs. The iRAT and tRAT questions are identical. Collaboration takes place in the tRAT and the application exercises, giving students the opportunity to teach each other through discussion. Application exercises are in-class assignments following the tRAT that allow teams to apply knowledge to real-life scenarios (11,14). Flipped classroom is another branch of active learning where students are required to study the material ahead of time, in order to be prepared for an assessment of their knowledge using audience polling (13). The polling allows for collaborative discussion among students and professor.

The overarching difference of these two pedagogies is that if conventional didactic teaching is a monologue by the instructor, then active learning is a dialogue between the instructor and the students.

Flipped Classroom in Graduate Level Health Care Programs

Team-based learning (TBL) has been studied in a widespread group of colleges of pharmacy and medicine across the United States. From northern California to Virginia, professional schools using TBL as part of the flipped classroom have improved average student achievement in course outcomes. The past success rates of TBL in these colleges were all compared to the average grades of classes following the conventional style of teaching. After being introduced at the College of Pharmacy at California Northstate University, unit examination grades “improved from 81% to 86%”(1) . However, the difference between lecture style and team-based learning was even more noticeable when 23% of the endocrine module class of 2013, using TBL, received an overall course grade of A, while only 9.5% of the class prior received an A using LBL. In another study, first year students at Touro University School of Pharmacy also demonstrated the efficacy of the flipped classroom when comparing scores from pharmacology and therapeutics classes with the traditional lecture style method from the year prior. The mean examination scores for the intervention and control groups were “89.6 vs 56.8 for pharmacology and 89.2 vs. 73.76 ($p<0.001$) for the therapeutics class”(4). This stark difference in student achievement further evidences the efficacy of the flipped classroom / TBL method compared to the traditional LBL method. In northern Virginia, similar results were determined by implementing a flipped classroom model to teach the renal pharmacotherapy module, resulting in improved student performance and favorable student perceptions about the instruction approach (5). Furthermore, it has shown improved achievement of course learning objectives in comparison to lecture-based methods.

On the other hand, some studies have not shown any statistically significant differences between flipped and unflipped classroom settings. The basic sciences class at Touro University is one example. Because of the nature of the course, the control group (unflipped) already had “a relatively high mean examination score;” therefore, determining improvement within the course based on teaching style proved difficult (4).

Graduate Medicinal Biochemistry Class Format by Dr. Melissa Beck

The four cohorts involved in this study were given the same material in different mediums. For example, the biochemistry students of the 2013 and 2014 classes utilized both TBL and LBL. This meant that they were given the option to review class material before the lecture would be given, but were not required to do so. These students were given two hours of lecture prior to any assessments such as iRATs, tRATs and application exercises. This model is a derivative of both active and passive learning methods. The two following cohorts of 2015 and 2016, however, were required to review material before the first class period as they were given preparatory quizzes that contributed towards their grade. Additionally, there was no lecture period, the instructor instead asked questions regarding the already studied material in order to clarify any misunderstandings and solidify the material. This model exemplifies active learning using a flipped classroom approach because it required the participation of the class in the learning process. All four cohorts were involved in learning that implemented TBL and assessed using the same format of iRATs, tRATs, and application exercises on a weekly basis.

Purpose Statement

Research Question

Will the implementation of "flipped classroom" curriculum, as opposed to lecture-based education, combined with TBL impact student performance in a graduate-level biochemistry course?

Purpose

The purpose of this study is to compare the achievement in course outcomes of four cohorts of students, two from each format, following flipped classroom setting versus traditional lecture setting within Cedarville University School of Pharmacy's Medicinal Biochemistry Class.

Objective

To determine the efficacy of flipped classroom with TBL on the learning outcomes of students in a graduate level biochemistry course.

Hypotheses

The null hypothesis that that the implementation of flipped classroom with TBL will not have an effect on student performance on course objectives in a graduate level biochemistry course.

The alternative hypothesis is that the implementation of flipped classroom with TBL will have an effect on student performance on course objectives in a graduate level biochemistry course.

Methodology

Study Design

This study is a case-control design, as the control group correlates to the passive learning cohort, while the case is the cohort that undergoes active learning via a flipped classroom setting. The investigation is retrospective because all data was collected throughout the semester and analyzed after the class ended; the study conforms to a single-blind model because data will be coded to the investigators in order to protect the identity of the individuals, but the individuals know in advance the intervention they will receive as they were given a syllabus at the beginning of the semester. Blinding is done to avoid Family Educational Rights and Privacy Act (FERPA) violations by the investigators.

Sample Selection

This study will use a non-probability, convenience sample of students from Cedarville University. Those included will be enrolled in Medicinal Biochemistry in the fall of the years 2013-2016. Inclusion criteria incorporates Doctor of Pharmacy (Pharm.D.) students and Bachelor of Science in Pharmaceutical Sciences (BSPS) students. No exclusions from these populations will be made.

Data Collection

The data concerning individual scores will be obtained via the instructor; however names and all identifying information will be removed, and data will be coded to maintain anonymity, for ethical considerations. Exam responses and assessment scores will be divided by topic in order to compare across years as ordering of material may have changed year to year. Data collection will only take into consideration the raw, unadjusted results from both the exams and the assessments. Coded iRAT and tRAT scores will be collected in addition to the exam scores. Because human subjects will be involved, a proposal will be submitted to an Institutional Review Board (IRB) for approval prior to data analysis.

Survey Development

Survey questions were developed in order to gauge student perceptions of the change in teaching and learning style. The five demographic questions were chosen in order to provide flexibility in statistical analysis. Based on the participants' answers to these first five questions, we will be able to sort and filter out any combination of exam and assessment scores. The four categorical questions specifically gauged the student perception of study habits, exam and assessment environment, and a preference for either one of the two teaching styles.

Literature was not consulted as the survey is not required for statistical analysis pertaining to the study, but could explain some differences encountered within the study. A list of sample questions is given in the table below. These question vary in type and were developed based on what the investigators believed would demonstrate correlation. Qualtrics will be use for further survey development and administration. The survey will be administered during the spring semester of 2016 and three reminders will be sent to the sample to complete the survey.

Type	Questions
Demographic/Close-ended	Did you complete your undergraduate studies at Cedarville? (MC options: Yes, No)
Demographic/Close-ended	What was your overall undergraduate GPA? (MC options: <2.5, 2.5-2.74, 2.75-2.99, 3.0-3.24, 3.25-3.49, 3.5-3.74, 3.75-4.0)
Demographic/Close-ended	What is your gender? (MC options: Male, Female)
Demographic/Close-ended	How old were you when you took biochemistry? (MC options: <18, 18-25, 26-30, 31-35, 36+)
Demographic/Open-ended	What was your average overall grade in Organic Chemistry I and II?
Categorical/ Close-ended	Are you a procrastinator? (MC options: Yes, No)
Categorical/ Partial open-ended	Do you prefer active learning or passive learning? Please briefly explain your preference. (Definition will be provided) (MC options: Active learning, Passive learning)
Categorial/ Close-ended	Which program were you enrolled in when you took Medicinal Biochemistry? (MC options: Pharm.D. program, BSPS program)
Categorial/ Close-ended	Which exam format do you prefer? (MC options: Paper, Electronic)

Analysis

Significance Criterion, Power, Sample Size

The alpha level will be set at 0.05.

Statistical power is the chance that we will detect an effect; it is determined by the alpha level, sample size and effect size. Effect size is the correlation between two variables such as the regression coefficient. From this definition, it does support our research analysis to determine the power in order to find a statistically significant difference, if one exists. If a study has high statistical power, the probability of giving a false positive result decreases, concluding there is no effect, when there is one. For example, if the results of the study indicate there is no difference between hybrid TBL and pure TBL, when there is a difference, a false negative result would have been found.

Since this is a retrospective study, sample size was not calculated. However, all Pharm.D students for classes 2013-2016 including the BSPS students that were enrolled in Medicinal Biochemistry will be included in the study.

Data Entry and Storage

The quantitative portion including the scores for iRATs, tRATs and exams related to Medicinal Biochemistry will be supplied by Dr. Melissa Beck for all students who completed the course from 2013-2016. The survey results that will be collected and stored using the Qualtrics survey tool will be processed into SPSS and quantified as a number variable. This number variable will directly correspond to a multiple choice response in the survey. Open ended-survey questions will be manually processed and grouped. Survey answers will be collected and stored by Qualtrics. Both Excel and SPSS files will be used to store exam, assessment, and survey data.

Statistical Program Utilized

SPSS is the stock statistical analysis program that Cedarville University offers free of charge to students. Moreover, SPSS will allow our team to easily import information directly from the Qualtrics survey results. Furthermore, SPSS is flexible because it seamlessly presents the results of multiple statistical tests on the same set of data. The statistical tests can also be performed based on one demographic variable, several demographic variables, or any combination of variables which will allow our team to assess findings from a multitude of perspectives.

Statistical Analyses

In order to ascertain and account for a plethora of factors that could potentially lead to misguided conclusions, descriptive statistics will be run per the results of the Qualtrics survey. Once descriptive statistic tests are run, our team will be able to sort, organize, and filter these factors and examine whether differences in the survey responses affected the objective. After this test, a simple comparison between the combined 2013 and 2014 class results versus the combined 2015 and 2016 results will be performed using an independent t-test. The independent t-test will only compare the mean results and will provide a starting point for the remainder of the statistical analyses. Additionally, a one-way ANOVA test will be used to compare 4 classes: 2013, 2014, 2015, and 2016. In the case that there are indeed significant differences, a two-tailed post-hoc comparison using a Bonferroni correction will assess the extent of these differences and will reduce the risk of a Type I error.

Additionally, the use of both the two-way ANOVA and ANCOVA will facilitate the additional insight regarding the study. The two-way ANOVA test will allow the comparison of two or more factors for mean differences on a single continuous dependent variable. These factors will include a continuous independent variable such as age and nominal variables such as undergraduate status and gender. The ANCOVA will enable the study of the main independent variable (the use of pure TBL versus hybrid TBL) with and without covariates. The covariates, which will be obtained from the Qualtrics survey, will include continuous factors such as age, grade in Organic Chemistry, and GPA. The ANCOVA test is necessary to control for factors that would otherwise convolute results between the different cohorts. By using ANCOVA, we will be able to best control covariates, rather than be confused by covariates that may appear at a later point in time.

There are three assumptions that the 2-way ANOVA must meet: normal distribution, independent samples, and same sample size. There are three assumptions that the ANCOVA must meet: independent samples, normal distribution, and a specific value of the covariate for any one level of a factor. The assumption of normality will have to be proven by data which has yet to take place; this will be assessed by the Shapiro-Wilk test.

Timeline, Limitations, Future Directions

The survey development will be complete by winter 2015. IRB submission and survey distribution by email will take place in the spring of 2016. Upon completion of medicinal biochemistry by students in the fall of 2016, the data collection will end. All analysis will be completed and conclusions drawn by the spring term of 2018.

There are limitations inherent in every study and in this study they include the use of point biserial, aberrant testing conditions, and a change in testing style. The use of point biserial limits the questions that are used in the following years because it removes questions based on results of previous years. Furthermore, the first two cohorts that took the class were tested using the conventional paper method that was then graded by machine whereas the following two cohorts used the software ExamN for all tests. This change in testing conditions could be a confounding variable; additionally, one major exam experienced aberrant testing conditions as the internet was unavailable which caused delay introducing another confounding variable.

Recommendations for the future direction of this project are to implement the flipped classroom with TBL approach into multiple classes simultaneously to determine the efficacy of the approach on a broad scale.

References

1. Ofstad W, Brunner L. Team-Based Learning in Pharmacy Education. *American Journal Of Pharmaceutical Education* [serial online]. April 2013;77(4):1-11.

2. Thompson B, Schneider V, Richards B, et al. Team-based learning at ten medical schools: two years later. *Medical Education* [serial online]. March 2007;41(3):250-257.

3. Opdecam E, Everaert P, Keer H, Buysschaert F. Preferences for Team Learning and Lecture-Based Learning Among First-Year Undergraduate Accounting Students. Research In Higher Education [serial online]. June 2014;55(4):400-432.

4. Wong T, Ip E, Lopes I, Rajagopalan V. Pharmacy Students' Performance and Perceptions in a Flipped Teaching Pilot on Cardiac Arrhythmias. *American Journal Of Pharmaceutical Education* [serial online]. December 16, 2014;78(10):1-6.

5. Pierce R, Fox J. Vodcasts and Active-Learning Exercises in a "Flipped Classroom" Model of a Renal Pharmacotherapy Module. *American Journal Of Pharmaceutical Education* [serial online]. December 2012;76(10):1-5.

6. McLaughlin J, Griffin L, Mumper R, et al. Pharmacy Student Engagement, Performance, and Perception in a Flipped Satellite Classroom. *American Journal Of Pharmaceutical Education* [serial online]. November 2013;77(9):1-8.

7. Punja D, Kalludi S, Pai K, Rao R, Dhar M. Team-based learning as a teaching strategy for first-year medical students. Australasian Medical Journal [serial online]. December 2014;7(12):490-499.

8. Wallace ML, Walker JD, Braseby AM, Sweet MS. "Now, what happens during class?" using team-based learning to optimize the role of expertise within the flipped classroom. Journal on Excellence in College Teaching. 2014;25(3):253-273.

9. Velegol SB, Zappe SE, Mahoney E. The evolution of a flipped classroom: Evidence-based recommendations. Advances in Engineering Education. 2015;4(3):1-37.

10. Phillips CR, Trainor JE. Millennial students and the flipped classroom. Journal of Business & Educational Leadership. 2014;5(1):102-112.

11. Tan N, Kandiah N, Chan Y, Umapathi T, Lee S, Tan K. A controlled study of team-based learning for undergraduate clinical neurology education. BMC Medical Education [serial online]. October 30, 2011;11:91.

12. Tune JD, Sturek M,Basile DP,. Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. Adv Physiol Educ. 2013;37(4):316-20.

13. Moraros J, Islam A, Yu S, Banow R, Schindelka B. Flipping for success: evaluating the effectiveness of a novel teaching approach in a graduate level setting. *BMC Medical Education* [serial online]. February 28, 2015;15:27.

14. Allen R, Copeland J, Lin A, et al. Team-Based Learning in US Colleges and Schools of Pharmacy. *American Journal Of Pharmaceutical Education* [serial online]. August 2013;77(6):1-9. Available from: Education Research Complete, Ipswich, MA. Accessed October 13, 2015.'

15. Waltz, C. F., Jenkins, L. S., & Han, N. (2014). The Use and Effectiveness of Active Learning Methods in Nursing and Health Professions Education: A Literature Review. Nursing Education Perspectives, 35(6), 392-400 9p. doi:10.5480/13-1168

16. Michel N, Cater III J, Varela O. Active versus passive teaching styles: An empirical study of student learning outcomes. *Human Resource Development Quarterly* [serial online]. Winter 2009;20(4):397-418. Available from: Business Source Complete, Ipswich, MA. Accessed October 15, 2015.

17. Hawks SJ. The flipped classroom: Now or never? *AANA J*. 2014;82(4):264-269 6p.