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How medical student adherence to assigned readings in a flipped classroom curriculum affects
their outcomes

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Scholarship in Medicine Final Report

Abstract

Objective: This study is aimed at finding out which level and type of preparation is most effective in helping students to achieve success in a flipped classroom curriculum.

Methods: Surveys were conducted regarding the percentage of required preparation students completed for each type of learning session (peer instruction, team-based learning), whether or not they used supplemental resources, and whether or not they completed >50% or < 50% of the required preparation. These were then compared to student scores on the type of learning activity through Spearman correlations and unpaired t-tests.

Results: The greater the percentage of required preparation completed typically resulted in higher test scores. Supplemental preparation did not directly correlate with higher test scores, with some cases showing a decrease in score with the addition of supplemental preparation. Completion of >50% of the required preparation typically resulted in higher test scores.

Key Words: flipped classroom, peer instruction, team-based learning

Introduction/Literature Review

The flipped classroom is a model of teaching and learning in which “students are doing the lower levels of cognitive work (gaining knowledge and comprehension) outside of class and focusing on the higher forms of cognitive work (application, analysis, synthesis, and/or evaluation) in class, where they have the support of their peers and instructor”¹. This method of educating has been implemented in various different teaching institutions, including dental schools, undergraduate curriculums, and medical schools^{1,2}. The consensus among many different studies is that the flipped classroom results in significant learning gains. “By providing an opportunity for students to use their new factual knowledge while they have access to immediate feedback from peers and the instructor, the flipped classroom helps students learn to correct misconceptions and organize their new knowledge such that it is more accessible for future use”³.

One of the primary learning activities is peer instruction (PI). This is where all students must answer conceptual questions (often via “clickers” or handheld personal response systems) independently and anonymously³. The instructor can see the class data immediately. If a large fraction of the class answers incorrectly, then students work together to come up with an answer while instructors circulate to promote productive discussions. After discussion, students answer the conceptual question again. The instructor provides feedback, explaining the correct answer and answering any additional student questions. This gets repeated for a certain number of questions each day.

Another frequently used learning strategy in the flipped classroom style is team-based learning (TBL). This is where students, again, do the required preparation outside of class and then come to class to do an individual assessment. After doing the assessment alone, the students

then take the same assessment again but as a group. This is intended to facilitate students working together to problem solve and teach each other what they know.

At the Boonshoft School of Medicine at Wright State University, both PI and TBL have been implemented in the classroom for the current first and second year classes. Each day of learning, regardless of whether it is a PI or TBL, requires students to come to class after doing the required and assigned preparatory work. This preparatory work is decided upon by Boonshoft School of Medicine staff and assigned to students via an online calendar. The assigned work varies, but usually contains a certain number of pages of textbook reading from a variety of sources. There is much debate about which resources are most effective for students during their independent preparatory work. Some institutions use a lot of videos and interactive technology, while others, like the Boonshoft School of Medicine, rely mostly on textbook reading⁴. A recent study has unveiled that student willingness to adapt to a flipped classroom approach versus a traditional classroom lecture style has an impact on student satisfaction with their learning⁴. Evaluating student success in a flipped classroom model is directly related to whether or not students adhere to the recommended assignments. The flipped classroom approach is new to the world of education, and there is controversy over its effectiveness in achieving desired learning outcomes⁵. There is a gap in literature in terms of advising which learning materials are most effective for students. More data collection is needed in order to evaluate the effectiveness of the flipped classroom model in a medical school curriculum, as no data currently exists. Evaluating the resources that best correlate with student success in the flipped classroom approach will help to fill this gap of knowledge. The significance of this study is to help all medical schools across the country that are implementing a flipped classroom approach to have knowledge of the resources that maximize student success.

This study is aimed at finding out which resources are most effective in achieving student success in the flipped classroom approach.

Hypothesis/Specific Aims/Research Questions

1. How does student adherence to instructor-assigned readings correlate with scores on engaged learning activities?
2. What was the effect of doing supplemental reading?
3. How does adherence to instructor-assigned readings correlate with individual MCQ and final exam scores for each module?

Methods

Context

Years 1 and 2 at the Boonshoft School of Medicine follow the WrightCurriculum. The WrightCurriculum consists of many different modules that each include Peer Instruction (PI), Team Based Learning (TBL), Multiple Choice Questions Tests (MCQs), and a final exam. Each module is a different length, but most last about 6-14 weeks. The scores for each learning session are recorded in a database. PIs are a single independent grade. This grade is derived from answering posted questions using a clicker device. If greater than 80% of the class answers the question correctly, then the first polled answer is counted for each student. If less than 80% of the class answers the question correctly, then the students are able to collaborate together and submit a new answer after ~2 minutes that is counted instead of the first polled answer. TBL scores are derived from both an individual quiz (IRAT) and a group quiz (GRAT) that are combined and each count towards 50% of the totaled TBL score. MCQ scores are comprised of an individual portion that counts for 70% of the total score and a group portion that counts for

30% of the total score. Before each learning session, faculty/instructors post a list of assigned readings on an online platform that the students are to complete in order to be prepared for the session. Whether or not students choose to do the assigned readings and/or add supplemental resources is their personal choice. The assigned readings are given based on what the instructors deem to be important and resources that they think are the most effective in teaching the concepts on which they will be testing.

Data Collection

This study used data collected by the Office of Medical Education. The data includes scores on Peer Instructions, Team Based Learning individual quiz grades, MCQ exams, and final exams. All of the collected data is deidentified. The data was taken from all students in years 1 and 2 of medical school participating in a flipped classroom curriculum, approximately 235 students. Data was also collected via student surveys filled out online after each learning session (PI, TBL) about how the students prepared for that particular session and why. A limitation of this project is that the surveys are both voluntary and subjective.

The questions being asked on the surveys included: 1) What percentage of the required preparation did you do prior to the session? 2) Did you do any supplemental preparation prior to the session? If yes, please list what supplemental resources you used. 3) Give reasons for your choice and use of preparation materials.

The courses the students were taking while we surveyed them and collected data on their scores include Balance, Control, & Repair, Beginning to End, Human Architecture, and Host and Defense. The score that was used for data analysis of the PI sessions was the “first poll” score, not the “second” or “post-discussion” score. The score that was used for data analysis of the TBL

sessions was only the “IRAT” score, not the “GRAT” score. The score taken from the MCQs was just the individual score, not the group score; the final exam score was individual only.

Data Analysis

We used the collected deidentified data to show what percentage of the required resources students were using and how the used resources related to students' scores. We correlated PI first poll scores, TBL IRAT scores, PI + TBL scores combined, Average MCQ scores, and Final Exam scores with the percentage of required preparation done by the students. This was done using Spearman correlations. We then evaluated how the use of supplemental preparation affected scores of PIs and TBLs. PI and TBL scores, separately, were compared with whether or not the students completed >50% or <50% of the assigned reading for each module. These were done using unpaired T-tests.

Results

Host and Defense

When investigating how percentage of preparation for PIs, TBLs, and both PIs and TBLs together correlate with their respective scores, Spearman correlations indicated a small but significant correlation ($r = .135$, $p = .012$) between PI, a moderately significant correlation ($r = .493$, $p = .001$) with TBL, and a small but significant correlation ($r = .180$, $p < .001$) with PI and TBL together, all whereas the percentage of preparation increases the scores also increase.

When investigating how percentage of preparation correlates with Final Exam scores and Average MCQ/Final Exam scores, Spearman correlations indicated no significant correlation ($r = .315$, $p = .051$; $r = .252$, $p = .127$; respectively).

Neither PI nor PI + TBL scores were significantly different between those who used supplemental preparation and those who did not ($t = .130, p = .897$; $t = -.905, p = .366$; respectively) (Table 1). However, TBL scores were significantly different between those who used supplemental preparation and those who did not ($t = -2.422, p = .02$) (Table 1).

Table 1: Mean Scores According to Supplemental Preparation

Modality	Sup Prep	n	Mean	SD
PI	No	265	69.60%	14.09%
	Yes	81	69.37%	13.58%
TBL	No	33	61.52%	20.33%
	Yes	8	80.00%*	14.14%
PI + TBL	No	298	68.71%	8.31%
	Yes	89	70.33%	9.90%

Abbreviations: SD, Standard Deviation

Sup Prep= Preparation

* Significantly different than no preparation group ($p < .05$)

No students reported that they did <50% of the required prep for either PI or TBL, so mean scores between those who reported completing <50% of the required prep and those who reported completing >50% of the required prep could not be compared.

Human Anatomy

When investigating how percentage of preparation for PIs, TBLs, and both PIs and TBLs together correlate with their respective scores, Spearman correlations indicated a small but significant correlation ($r = .201, p = .018$) between PI, no significant correlation ($r = .03, p = .848$) with TBL, and a small but significant correlation ($r = .162, p = .03$) with PI and TBL together, whereas the percentage of preparation increases the scores also increase.

When investigating how percentage of preparation correlates with Average MCQ/Final Exam scores, Spearman correlations indicated no significant correlation ($r = .065$, $p = .651$).

Both PI and PI + TBL scores together were significantly different between those who used supplemental preparation and those who did not ($t = 2.462$, $p = .015$; $t = 2.256$, $p = .025$; respectively) (Table 2). However, TBL scores were not significantly different between those who used supplemental preparation and those who did not ($t = -2.422$, $p = .02$) (Table 2).

Table 2: Mean Scores According to Supplemental Preparation

Modality	Sup Prep	n	Mean	SD
PI	No	120	60.04%	19.70%
	Yes	17	47.63%*	17.49%
TBL	No	35	43.71%	18.64%
	Yes	8	43.75%	25.60%
PI + TBL	No	155	56.36%	20.58%
	Yes	25	46.39%*	19.96%

Abbreviations: SD, Standard Deviation

Sup Prep= Preparation

* Significantly different than no preparation group ($p < .05$)

PI scores were not significantly different between those who did >50% of the required preparation (58.9730%) and those who did <50% of the required preparation (46.0840%) ($t = -1.433$, $p = .154$) (Table 3).

Table 3: Average Score Based on Preparation Level for PIs

Prep	n	Mean	SD
1	5	46.0840%	9.07480%
2	132	58.9730%	19.97174%

Abbreviation: SD, Standard Deviation

Prep= Preparation

<50% of Required Preparation=1; >50% of Required Preparation=2

No students reported that they did <50% of the required prep for TBL or Avg MCQ/Final Exam, so mean scores between those who reported completing <50% of the required prep and those who reported completing >50% of the required prep could not be compared.

Beginning to End

When investigating how percentage of preparation for PIs, TBLs, and both PIs and TBLs together correlate with their respective scores, Spearman correlations indicated a small but significant correlation ($r = .191, p < .000$) between PI, a moderately significant correlation ($r = .261, p = .046$) with TBL, and a small but significant correlation ($r = .199, p < .000$) with PI and TBL together, whereas the percentage of preparation increases the scores also increase.

When investigating how percentage of preparation correlates with MCQ Average scores and NBME scores, Spearman correlations indicated no significant correlation ($r = .147, p = .161; r = .024, p = .822$; respectively).

When investigating how use of supplemental preparation for PIs, TBLs, both PIs and TBLs together, MCQ averages, and NBME exams correlate with their respective scores, Spearman correlations indicated no significant correlation between PI, TBL, or PI and TBL together ($r = -.008, p = .886; r = -.278, p = .075; r = -.016, p = .753; r = 0.021, p = .875; r = -.097, p = .477$; respectively).

Both PI and TBL scores were not significantly different between those who did >50% of the required preparation and those who did <50% of the required preparation ($t = -1.176, p = .240; t = -1.939, p = .058$; respectively) (Table 4). However, PI + TBL together scores were

significantly different between those who did >50% of the required preparation and those who did <50% of the required preparation ($t = -2.345$, $p = .019$) (Table 4).

Table 4: Mean Scores According to Level of Preparation >/< 50%

Modality	% Prep	n	Mean	SD
PI	<50	19	61.01%	15.38%
	>50	763	65.29%	15.67%
TBL	<50	5	41.33%	18.50%
	>50	52	54.59%	14.25%
PI + TBL	<50	24	59.91%	17.64%
	>50	815	64.60%*	15.80%

Abbreviations: SD, Standard Deviation

Prep= Preparation

* Significantly different than no preparation group ($p < .05$)

Balance, Control, and Repair

When investigating how percentage of preparation for PIs, TBLs, and both PIs and TBLs together correlate with their respective scores, Spearman correlations indicated a small but significant correlation ($r = .155$, $p < .001$) between PI, no significant correlation ($r = .200$, $p = .071$) with TBL, and a small but significant correlation ($r = .156$, $p < .001$) with PI and TBL together, whereas the percentage of preparation increases the scores also increase.

When investigating how percentage of preparation correlates with Average MCQ and NBME scores, Spearman correlations indicated no significant correlation ($r = .174$, $p = .113$; $r = .109$, $p = .327$; respectively).

PI, TBL, and PI + TBL together scores were not significantly different between those who used supplemental preparation and those who did not ($t = -1.874, p = .061$; $t = 1.221, p = .226$; $t = -1.631, p = .103$; respectively) (Table 5).

Table 5: Mean Scores According to Supplemental Preparation

Modality	Sup Prep	n	Mean	SD
PI	No	798	66.13%	15.67%
	Yes	409	67.88%	14.58%
TBL	No	44	71.82%	11.53%
	Yes	38	67.98%	16.74%
PI + TBL	No	842	66.43%	15.53%
	Yes	447	67.89%	14.76%

Abbreviations: SD, Standard Deviation

Sup Prep= Preparation

* Significantly different than no preparation group ($p < .05$)

Both PI and PI + TBL together scores were significantly different between those who did >50% of the required preparation and those who did <50% of the required preparation ($t = -3.328, p = .001$; $t = -.310, p = .002$; respectively) (Table 6). However, TBL scores were not significantly different between those who did >50% of the required preparation and those who did <50% of the required preparation ($t = -.539, p = .591$) (Table 6).

Table 6: Mean Scores According to Level of Preparation >/< 50%

Modality	% Prep	n	Mean	SD
PI	<50	190	63.40%	15.23%
	>50	1010	67.31%*	15.29%
TBL	<50	22	68.64%	14.61%
	>50	60	70.56%	14.17%

PI + TBL	<50	212	63.94%	15.22%
	>50	1070	67.50%*	15.24%

Abbreviations: SD, Standard Deviation

Prep= Preparation

* Significantly different than no preparation group ($p < .05$)

Discussion

This research was conducted in an effort to better determine which study strategies are most effective in a flipped classroom curriculum. This type of curriculum emphasizes independent learning which is greatly affected by study methods². This research would ideally help students to determine the most effective study strategies and help the curriculum writers in guiding students towards success.

For the 4 classes that were researched (HA, HD, B2E, and BCR), a higher percentage of required preparation completed tends to lead to higher scores on both PIs and TBLs. This helps to answer the research question of “how does student adherence to instructor-assigned readings correlate with scores on engaged learning activities?”. The correlations were small but significant for most of the classes. For HA specifically, the type of required preparation was videos created by the faculty member who designed the final exam. Due to this, most students probably adhered tightly to the assigned preparation, as it would likely contain the information that faculty member deemed important. The Host and Defense course had a final exam that was made by the faculty at Boonshoft SOM, not an outside organization like NBME. The NBME questions are selected by Boonshoft SOM faculty, but they are not written by them. For that reason, it also supports why students adhered tightly to doing the required preparation. Both B2E and BCR had NBME exams at the end of the courses. This could have encouraged students to do

less of the required preparation, as the final exam is written from an organization outside of the Boonshoft SOM.

Next, the effect of supplemental preparation on scores was evaluated. Most of the statistical analyses indicated no significant difference in scores for those who did supplemental preparation versus those who did not. This helps to answer the research question of “what was the effect of doing supplemental reading?”. For the Human Anatomy course, PI + TBL together scores actually went down with the use of supplemental preparation. This could be due to students not doing enough of the required preparation and instead using supplemental preparation. There is a high probability of students missing important information that might only be covered in the required preparation. In addition, the personality type of students who would choose to do supplemental preparation instead of the required preparation could also be reflected in who decided to answer the surveys⁴. If those students did not feel the need to adhere to the assigned readings, they may have also not felt the need to complete the assigned surveys. The type of supplemental preparation could also have an affect on scores, as certain supplemental materials could be more helpful or informative than others⁵.

This study grouped level of preparation as either >50% of required preparation completed or <50% of required preparation completed and then evaluated how the groups' scores differed. For this data, some of the significance was unable to be determined because some groups had every person completing >50% of the required preparation. This happened in the Human Anatomy course and makes sense, as I stated earlier that the required preparation was videos created by the faculty member who designed the final exam. It also occurred in the Host and Defense course, which had a faculty created final exam. For most of the other groups, there was a significant difference. Those who completed >50% of the required preparation tended to have better scores

than those who did <50% of the required preparation. This is a logical finding, as more preparation often leads to better understanding of a topic⁴.

Overall, this study indicates that the most effective form of preparation to ensure higher test scores is variable and based on the individual. Greater amount of preparation completed will likely result in higher test scores, however it is not clear which method of preparation is most effective (i.e. textbook reading, videos, etc.). Supplemental preparation does not directly correlate with higher test scores, so that option is up to the individual learner. As stated in the literature review, a recent study has unveiled that student willingness to adapt to a flipped classroom approach versus a traditional classroom lecture style has an impact on student satisfaction with their learning⁴. The willingness to adapt to this new type of curriculum could likely contribute to student success. More research, with a potentially greater sample size, will be required to determine if significant changes need to be made to study strategies or resources used in the WrightCurriculum to ensure student success.

Conclusion

There were many limitations to this study. One of the most significant limitations was who chose to do the surveys. Many people chose not to complete them or put down false answers to the survey questions. There could also be certain types of traits within individuals that impacted whether or not they completed these surveys. These same traits could affect how these individuals prepared for PIs and TBLs. Another limitation is that students could be answering the surveys without remembering how they prepared, as many of the surveys were completed well after the time the preparation took place.

In the future, it could be helpful to the students at the Boonshoft SOM for research to continue on this subject. The foundational knowledge learned in the first two years of medical

school is paramount to success both on the national board exams and on future clinical practice. Continuing to determine which materials should be assigned to students and how they can best utilize these resources will ultimately help students to find success in a flipped classroom curriculum.

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