# The Impact of Learning Styles on Student Performance in Flipped Pedagogy

Joshua C. Nwokeji & Terry S. Holmes
Interdisciplinary Research Group (IRG), College of Engineering and Business
Gannon University Erie, Pennsylvania USA; Email:[Nwokeji001,holmes002]@gannon.edu

***Abstract*—Flipped classroom is an emerging pedagogical model with potentials to support active engagement and improve student performance. This research empirically validate the impact of: 1) Flipped classroom on student performance; and 2) Preferred learning style on student performance in a flipped classroom. We designed an experiment to compare the performance of students in flipped classroom with traditional teaching method. This experiment involves a total of 35 students. The students were divided into two separate classes (01 and 1E) taught by the same professor with the same contents and assessment methods. Students in Class 01 are the 'experiment group' and were taught with flipped method, while students in Class 1E are the 'control group' and were taught with traditional method. Data was collected from three components of student assessment (Participation, Homework, and Exam) and questionnaire; we used the questionnaire to group students by their preferred learning styles. The key findings after data analysis include a) Students in flipped classroom achieved 7% higher 'Participation Grade' than their peers in traditional. b) Students in traditional classroom achieved 17% higher 'Homework Grade' and 6% higher 'Exam Grade' than their peers in flipped classroom. c) Logical Learners outperformed Visual Learners by 10% in flipped classroom. Further, we discussed the implications of these findings to practice. We expect this paper to be useful and informative to higher education instructors who adopt or plan to adopt flipped classroom in their courses.**

## I. Introduction

Typically, learning should be a collaborative initiative between an instructor, who is a subject-matter expert, and a learner (student). The learning process therefore involves two key activities, namely, impartation of knowledge (lecture/teaching) from the instructor and active participation and learning from the student [1, 2, 3]. The location and order in which these two activities occur give rise to two broad methods of instruction or pedagogical models, i.e., traditional and flipped classroom models. In a traditional pedagogical model, knowledge impartation normally occurs in the classroom through lectures, tutorials, etc.; while students are expected to participate by completing homework and assignments outside the classroom, usually at their homes [4, 5]. The flipped classroom model, on the other hand, is a paradigm shift that reverses the order and location in which learning activities occur in the traditional model. Fundamentally, in a flipped classroom model, knowledge impartation takes place at home through prerecorded video lectures and tutorials, while students spend class times participating in homework (classwork) and assignments [6, 7].

The flipped classroom model received greater attention and became more popular when two high school teachers, Bergemann and Sam [7, 8, 9], pioneered it with the intention to actively engage students in a Chemistry class. Before this time, few institutions experimented on a similar model called 'inverting the classroom' [10, 11]. Bergemann and Sam [6, 7] outline the perceived benefits of adopting the flipped classroom model. These include improved student performance; enhanced student engagement and participation in class activities; more time for collaborative and active learning; and the ability to pause, rewind and replay lecturers [6, 9]. These perceived benefits were derived from a single subject in a high school context, and thus may not be generalized. In addition, they may not be applicable to all courses in a higher education context, since curriculum contents, learning outcomes, and difficulty levels can be different in both contexts.

A review of literature shows that one major motivation for adopting and implementing flipped classroom in higher education is the reported benefit of improved student performance. This reported benefit is however largely based on heuristic observations and qualitative surveys, instead of empirical validation with quantitative data. Thus, it can be difficult to guarantee that the flipped classroom can offer the benefit of improved student performance. As discussed later in Section II, the very few scholars that empirically validate the impact of flipped classroom on student performance found conflicting results; some reported positive impact and others reported negative impact. There are also others who found neutral or no significant impact at all. Additionally, none of these scholars considered how or if student preferred learning styles can affect performance in flipped classroom. There is therefore the need for more research to empirically validate the impact of flipped classroom on student performance and the effect of student preferred learning styles.

To address the above mentioned limitations, this research empirically validate the impact of: 1) Flipped classroom on student performance; and 2) Preferred learning style on student performance in a flipped classroom. We designed an experiment to compare the performance of students in flipped classroom with traditional teaching method. This experiment involves a total of 35 students. The students were divided into two separate classes (01 and 1E) taught by the same professor with the same contents and assessment methods. Students in Class 01 are the 'experiment group' and were taught with flipped method, while students in Class 1E are the

978-1-5090-5920-1/17/$31.00 ©2017 IEEE

'control group' and were taught with traditional method. Data was collected from three components of student assessment (Participation, Homework, and Exam) and questionnaire; we used the questionnaire to group students by their preferred learning styles.

We expect this paper, especially the results, analysis, and discussion of our experiment, to be useful and informative to higher education instructors who adopt or plan to adopt flipped classroom model in their courses. To enhance readability, we organize the rest of this paper as follows: Section II reviews scholarly related work on the impact of flipped classroom on performance. This is followed by Section III where we described the design of our experiment. Then, the collection and analysis of data are discussed in Section IV. This is followed by findings, analysis and discussion in Section V, while conclusion and future work are presented in Section VI.

## II. Review of Related Work

A typical flipped classroom pedagogy involves the creation of some form of multimedia contents, such as videos and podcasts, used for the delivery of traditional lecture content outside of the classroom. Students are expected to watch the multimedia contents before class, and by so doing free up the class time for learning activities other than traditional lecture [10, 12]. Thus, the term flipped or inverted classroom obtained its name [13]. These learning activities normally focus on active or inquiry based learning by the individual student, possibly in a group task or project. After investing time to create the multimedia content, the instructor's focus shifts to the in-class inquiry based learning activities such as group discussions and collaborative problem solving.

Scholars who implement flipped pedagogy generally agree and report the various benefits derived from such initiative; these include improved performance [14, 3], effective management of class time [4, 15], enhanced student participation and engagement [16, 17], among others. But most of these benefits are based on qualitative observation rather than quantitative validation. The few scholars who quantitatively validated the effect of flipped classroom on student performance obtained conflicting results. These can be grouped into three major categories.

The first category of scholars (positive impact) found that students in flipped classroom performed better than their peers in traditional classroom [14, 3]. The second category (neutral impact) found no significant difference in the, or equal, performance between students in flipped and traditional classroom [4, 15]. The third category (negative impact) found that students in traditional outperformed students in flipped classroom [16, 17]. These variations in results might be as a result of the difference in the nature, variables, and objects of the experiment. For instance, as discussed in the proceeding paragraphs, these experiments were conducted with different type of students (Seniors, Juniors, Sophomores, Freshmen); different institutions (two year college, masters college, doctoral college, etc.); different courses (STEM, Arts, etc.); and different number of students.

Bradford et al [14] and Amresh et al [3] are among the scholars who found that flipped pedagogy improved student performance when compared with traditional classroom. Both studies conducted experiment with undergraduate level courses. Bradford et al [14] (National College of Ireland) experiemented with 49 students of 'Introduction to Mathematics for Computing' while Amresh et al [3] (Arizona State University) experimented with 39 students in CS1-'Introductiory Computer Programming'. These courses were taught to students using flipped and traditional models. Data collection and analysis were based on student assessment (tests, assignments, homework, and exams). The analysis of these data shows an increased performance for students in flipped classroom in comparison with their traditional counterparts.

A similar experiment was design and carried out by scholars, such as Mason et al [4] and Ziegelmeier & Topaz [15], who found no significant difference in the overall performance of students in flipped and traditional classroom. For Mason et al, the experiment was conducted with 40 senior level-students (20 for flipped and 20 for traditional) of 'Control Systems' Course at Seattle University, USA, while Ziegelmeier & Topaz conducted with 45 students (22 flipped and 23 traditional) of AMC 1-'Applied Multivariable Calculus'. After analyzing student assessment data, both scholars found that students in flipped classroom performed as well as students in traditional classroom.

Moffett & Mill [16] and DeSantis et al [17] are among the scholars who found that students in traditional classroom outperformed their peers in flipped. The design and nature of their experiments is almost the same with the first two categories, the only difference is in the number of students, courses, and institutions.

The findings of these scholars, though contradictory, make useful contributions and can inform practice. However, a major limitation is that none of these scholars considers the implications of learning styles to student performance in both flipped and traditional classrooms. Taking students' preferred learning styles into account can help to reinforce the practice of flipped pedagogy, and provide a more accurate information regarding the effectiveness and benefits of flipped pedagogy. To address this limitation and lay the foundation for further studies, our experiment compares student performance, in both flipped and traditional model, with five (5) learning styles commonly preferred by students in engineering education [18], these are further discussed in Section IV.

## III. Experiment Design

The experiment design was approached with an underlying intent to test if flipped classroom can improve student performance, and if or how preferred learning styles can impact on student performance. In addition, we are also interested in understanding the validity of flipped classroom in achieving student learning and program outcomes in our College of Engineering and Business (CEB). Specifically, the following program outcomes were implemented in the two class sections. First, students will demonstrate critical thinking, analytical and

problem solving skills to identify, analyze, evaluate and solve business problems and capture business opportunities. Second, students will have the oral and written communication skills to effectively interact with stakeholders. Third, students will be able to integrate knowledge across the functional areas of business and utilize leadership and team-building skills to manage resources and achieve goals and objectives.

Employers throughout the United States are becoming more and more concerned at the deficient writing and interpersonal communication skills of recent graduates. In 2016, Forbes ( http://tinyurl.com/lu648y9) Magazine wrote an article on the skills bosses say new graduates do not have which includes writing proficiency, public speaking skills, lower-than-needed interpersonal and teamwork skills, critical thinking and problem solving, and paying attention to detail. The alarming trend of this deficiency may very well be caused by the advent and worldwide popularity of online gaming and social media. However, causation of recent graduates deficiencies is not the purpose of this research. It is important to note the ease at which writing, interpersonal skills, critical thinking and problem solving, and group task assignments lend themselves to the flipped classroom approach.

Our experiment consist of a total of 35 (thirty five) students who registered for BCOR 215. BCOR is one of the courses taught in the College of Engineering and Business (CEB) at Gannon University. BCOR 215 (Principles of Accounting II) focuses on managerial accounting with financial statement analysis. All BCOR courses are open to engineering and business majors. We randomly registered eighteen (18) students in the first Class of BCOR 215, hereafter called *Class 01*, while the other seventeen (17) students was registered in the second Class of BCOR 215, hereafter called *Class 1E*. Both Classes were taught by the same faculty member, Terry S Holmes, JD, MBA–Assistant Professor, in the same Semester –Spring 2017, the same building, on the same floor and with the same content and technology. Class 01, the experiment group, was taught using the flipped model and ran from 9:30 am until 10:50 am. On the other hand, Class 1E, the control/comparison group, was taught using the traditional model and ran from 4:30 pm until 5:50 pm.

Both Classes were provided the same lecture content (in flipped or traditional/face to face format), covered the exact same materials in the same quantity of time, assigned similar homework, and were tested in class with paper tests. The only notable differences were the time of day, the individual students as well as the order and location in which lecture and homework took place. The students were roughly the same in relation to age, gender, and national origin. Each student only signed up for one of the classes. As shown in Table I, the grading components (assessment criteria) for both classes were identical, except that Participation has higher points in traditional classroom than in flipped. This is because quizzes and interactive projects were attached to the videos in the flipped classroom, and assigned some points, to serve as motivation for students to watch the video. For the purpose of this experiment, we will consider the three grade components in Table I, since these are common to both flipped and traditional models.

TABLE I: Grading Components

| Assessment Criteria \ Instructional Method | Flipped | Traditional |
|---|---|---|
| Exam | 200 Points | 200 Points |
| Homework | 50 Points | 50 Points |
| Participation | 25 Points | 50 Points |

The comparison class, i.e., Class 1E, was a straight forward traditional lecture format. Each class started with the question: Are there any questions from last class? Then, the lecture explaining the current learning outcomes began. This lecture evolved into problem solving interactively with the students. Students were to attempt assigned homework online, and ask questions via email or during class and office hours. Additionally, students could ask questions on the Discussion Board inside the Blackboard Learning Management System. Homework was linked into the course inside the Blackboard Learning Management System. Further, the publisher site, Connect, enabled students to use publisher resources to assist in solving problems.

In Flipped Model, students were assigned video lectures to watch outside of class times and complete short quizzes at intervals, then spend most of the class time on projects and homework. Each video lecture was designed to be between 5 and 15 minutes long. The video lectures consisted of word documents; excel documents, and Portable Document Format (PDF) documents created by the Instructor. Then, the Instructor used Kaltura, an open source video format, to create the videos. The only items needed were a laptop with a video and microphone. Some lectures simply needed the microphone with the word or excel or PDF being the video portion. We used a headset microphone; however, this headset microphone was used out of habit. Kaltura enables you to crop the video and add subtitles and draw on the documents. There are many other ways to make the video; however, we wanted to keep the videos simply focusing on content, not video graphic abilities for the experiment.

## IV. Data Collection

For the purpose of validation, we collected both qualitative and quantitative data from a total of thirty five (35) students. For the qualitative data, we designed a short questionnaire with the 'SurveyMonkey' system and used it to collect data from students. The aim of this questionnaire was to identify students' preferred learning styles. These are important to us, since we are interested in finding out if or how learning styles have effect on students' performance in both flipped and traditional models.

For the learning styles, students were asked to select their primary learning style from a list of five (5) learning styles (see Figure 1) identified from [18]. We selected these learning styles because they are commonly used in engineering education [18]. Figure 1 shows the five learning styles identified and included in the survey questionnaire.

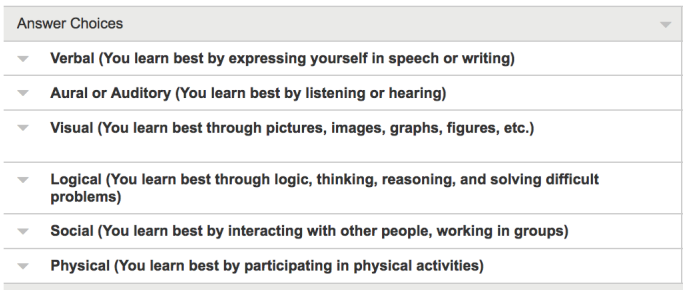



Fig. 1: *Stduent Learning Styles included in the Survey*

The quantitative data was primarily collected from students' grades. For clarity and fair comparison, we focus on the three 'grade components' that are identical to both Class 01 and Class 1E, these are Participation, Homework, and Exam, see Table I. Moreover, all points in Table I are converted to percentage scale. As shown in Figure 2, we also included the total score and plotted these in a bar chart. Additionally, in order to find out how student learning styles impact on their performance, we also plotted bar charts to compare each learning styles with the three grade components. Figure 3a shows the grade distribution in flipped classroom in relation to student preferred learning styles, while Figure 3b shows the grade distribution in traditional classroom in relation to student preferred learning styles. In the section that follows, we analyze these data and use them to discuss and support our findings.

## V. Findings, Analysis and Discussion

### A. Overall Performance: Flipped vs Traditional

(1). Students in our flipped classroom (Class 01) participated in the course more than students in traditional classroom (Class 1E). Figure 2 illustrates a significant increase of approximately seven percent (7%) in 'Participation Grade' for the flipped class when compared to the traditional class. This finding begs the question, why?. The exact answer and reason for this increased participation, is subject to further research, and beyond the scope of this study.

However, it is important to note that 'Participation Grade' was measured by in-class student interaction with fellow students and the instructor. Watching video lectures before the class, as required from flipped students, could spur thought on the new lecture content, resulting in the desire to ask questions of the Professor or fellow students. The traditional classroom students are expected to read the chapter before class. However, based on our experience and observation, most students are known to fail in this expectation; and thus come to class unprepared and ignorant of the lecture content/material. Such students would have little or no spurred thought, due to lack of prior exposure to lecture material, and are thus unlikely to ask questions and participate in class activities. This could be a possible explanation for this difference in participation grade.

(2). Students in traditional classroom achieved approximately 17% higher 'Homework Grade' than their peers in flipped classroom, this can be seen from the Chart in Figure 2. The homework was exactly the same for both groups with unlimited submission attempts subject to the deadlines. The homework consisted of the exact same questions as well as the exact same points per question. All homework questions were online and algorithmic, which implies that the words were the same; however, the numbers assigned to the question changed with each homework attempt.

This significant variation in 'Homework Grade' can attributed to resources, location, and time for Homework completion.Traditional classroom students are expected to complete their homework at home or outside the classroom, which gives more time to consult other resources and seek for help from peers. Unlike flipped students, who are required to watch videos outside of the class time; and thus may have lesser time and limited flexibility to consult other resources when compared with peers in traditional classroom. Further research would be needed to statistically confirm these explanations.

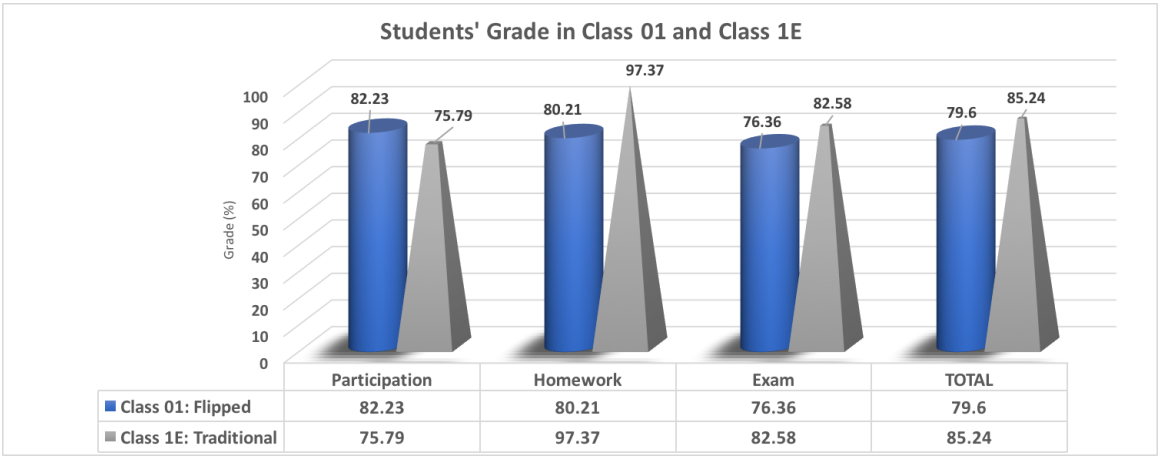
(3). As shown in Figure 2, students in traditional classroom achieved approximately 6% higher 'Exam Grade' than those in flipped classroom. The exams consisted of the exact same questions and included materials covered in the course textbook, homework, and lecture (traditional/video). The flipped and traditional students were informed of the need to complete all the homework to be ready for the exams; since some homework questions would be repeated in the exam. However, it is readily apparent, from 'Homework Grade', the flipped students had some challenges with completing their homework. As discussed in the preceding paragraph, traditional students solved homework questions better and outperformed flipped students, this might have contributed to the increase in the former's exam performance.

(4). Additionally, we found that the total performance of students in traditional classroom is approximately 6% higher than students in flipped classroom, see Figure 2. This is not surprising since traditional students outperformed their flipped counterparts with significant percentage in two of the considered grade components (Homework and Exam).

(5). Overall, using empirical data, see Figure 2, we found that students in the traditional classroom have better performance, in Homework and Exam, than those in flipped classroom. However, flipped pedagogy improved participation, engagement, and interaction among students. In the next section, we discuss our findings on the effect of learning styles on students performance in both flipped and traditional models.

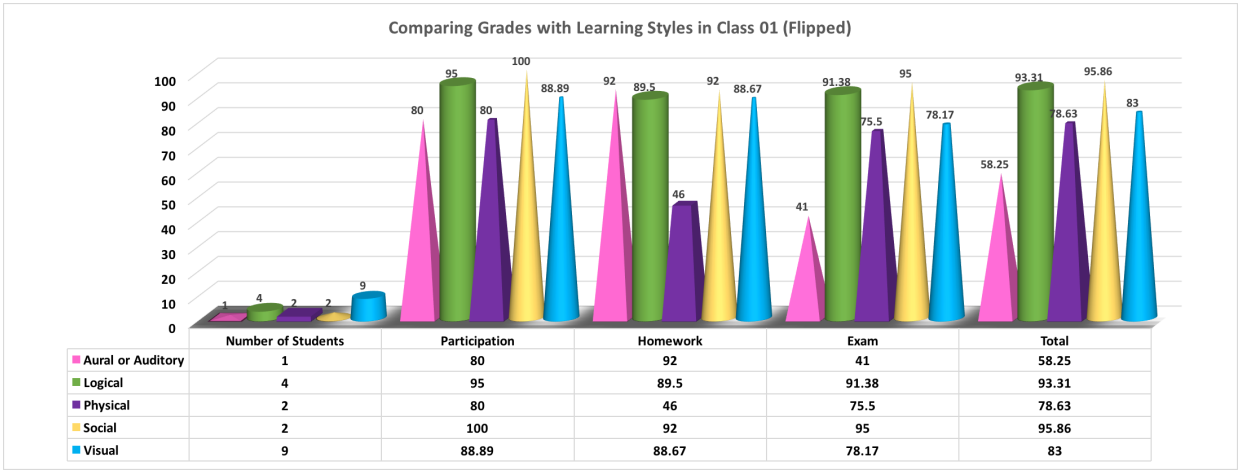
### B. Student Performance and Learning Styles

The vast majority of our students in both classes selected 'Visual' as their preferred learning style. This is supported by the Chart in Figure 3a, which shows that 9 (nine) out of 18 (eighteen) students preferred Visual Learning Style. Similarly, Figure 3b shows that 13 (thirteen) out of 17 (seventeen) students preferred Visual Learning Style. Other learning styles have 2 (two) learners each, except Aural which has only one.



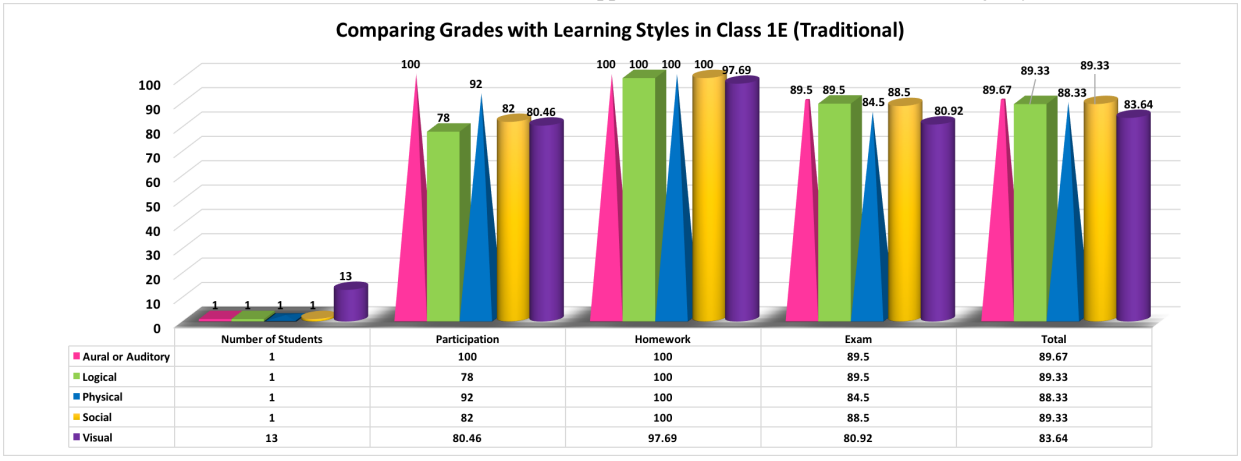

| | Participation | Homework | Exam | TOTAL |
|---|---|---|---|---|
| Class 01: Flipped | 82.23 | 80.21 | 76.36 | 79.6 |
| Class 1E: Traditional | 75.79 | 97.37 | 82.58 | 85.24 |

Fig. 2: Students' Average Percentage Grade in each Grading Component




| | Number of Students | Participation | Homework | Exam | Total |
|---|---|---|---|---|---|
| Aural or Auditory | 1 | 80 | 92 | 41 | 58.25 |
| Logical | 4 | 95 | 89.5 | 91.38 | 93.31 |
| Physical | 2 | 80 | 46 | 75.5 | 78.63 |
| Social | 2 | 100 | 92 | 95 | 95.86 |
| Visual | 9 | 88.89 | 88.67 | 78.17 | 83 |

(a) Grade Distribution in Flipped Classroom in Relation to Learning Styles




| | Number of Students | Participation | Homework | Exam | Total |
|---|---|---|---|---|---|
| Aural or Auditory | 1 | 100 | 100 | 89.5 | 89.67 |
| Logical | 1 | 78 | 100 | 89.5 | 89.33 |
| Physical | 1 | 92 | 100 | 84.5 | 88.33 |
| Social | 1 | 82 | 100 | 88.5 | 89.33 |
| Visual | 13 | 80.46 | 97.69 | 80.92 | 83.64 |

(b) Grade Distribution in Traditional Classroom in Relation to Learning Styles

Fig. 3: Comparison of Learning Styles with Grades for Both Flipped and Traditional Classroom Models

For the purpose of our discussion, we only consider those learning styles preferred by more than 2 students i.e., Visual and Logical, as statistically significant. Using the charts in Figure 3a and Figure 3b, we report the following findings.

(1). In flipped classroom, Logical Learners achieved approximately 6% higher 'Participation Grade' than Visual Learners, see Figure 3a. This finding is easily explained by the analogy: God gave humans two (2) eyes and one (1) mouth–Visual Learners, compared to God giving humans one (1) brain and one (1) mouth–Logical learners. The Visual learner will want to observe longer and then speak/interact. The Logical learner will want to discuss/argue sooner to develop their understanding. The homework grades are nearly identical for both logical and visual learners in the flipped classroom setting, approximately eighty-nine (89%) percent.

(2). Logical Learners in flipped classroom significantly surpassed the Visual Learners in the same classroom for Exam Grade. Figure 3a shows 'Exam Grade' of 91.38% for Logical Learners compared to 78.17% for Visual learners. This large performance gap could be because this course involves a lot of calculations, formulae and numerical analysis. The visual learners may very well be better suited for artistic and graphical design types of content, as opposed to numerical types of content. Yet, this is a hypothetical explanation, and would require further research and data analysis for confirmation. Logical learners consistently achieved higher grades for all other 'Grade Components' in flipped classroom, which is reflected in the 'Total Grade' of approximately 93% for Logical Learners and 83% for Visual Learners.

(3). Visual Learners in flipped classroom tend to participate more than Visual Learners in traditional classroom. As shown in Figure 3b, the 'Participation Grade' for Visual Learners was 80.46% percent for traditional classroom, which approximately 8% percent lower than the 'Participation Grade' of Visual Learners in flipped classroom (compare the Participation Grade in Figure 3a with Figure 3b ). Moreover, the 'Participation Grade' of Visual Learners in flipped classroom (88.89%, see Figure 3a) is higher than the 'Participation Grade' of all learners in flipped classroom (82.23%, see Figure 2). Thus, Visual Learners participate more across the board.

(4). Visual Learners in traditional classroom performed 9.02% in Homework more than the Visual Learners in flipped classroom (compare Homework Grade in Figure 3a and Figure 3b). Similarly, in Exam, Visual Learners in traditional classroom outperformed their counterparts in flipped classroom by 2.75%. Comparing Figure 3b with Figure 2 across the board, we discovered that the Homework Grade for Visual Learners in the traditional classroom (97.69%) is approximately equal to Homework Grade for all learners in traditional class (97.37, see Figure 2), but slightly (1.66%) lower in Exams.

### C. Limitations

We believe that the results of our experiment and the discussions and analysis thereof can be useful to practice. However, readers should be aware of some limitations of our experiment that can possibly threaten its validity. First is the 25 Points difference, See Table I, between the 'Participation Grade' of traditional and flipped classroom. Secondly, only students in flipped classroom were assessed with Quizzes and Interactive Project as well, which we used as motivation to make flipped students watch the video. However unlikely, there is a possibility that these variations in assessment can be a threat to the validity of our findings.

## VI. Conclusion and Future Work

This paper reports our effort to empirically validate the effect of flipped classroom on student performance; and to investigate if student preferred learning style impact performance in flipped pedagogy. We conducted an experiment with a total of 35 students, 17 of which were the experiment group (flipped classroom) while the other 18 students were control/-comparison group. Results from data collection and analysis show that students in flipped classroom tend to participate 7% more than their peers in traditional classroom. However, students in traditional classroom tend to perform 17% higher in Homework and 6% higher in Exam than their peers in flipped classroom. These results also suggest that Logical Learners performed 10% higher than Visual Learners in flipped classroom. Visual is the only statistically significant preferred learning style in our traditional classroom; a comparison shows that Visual Learners participated 8% better in flipped classroom than in traditional classroom. However, for Homework and Exam, Visual Learners in traditional classroom outperformed their peers in flipped classroom by approximately 9% and 3% respectively.

Flipped pedagogy is emerging and gradually becoming the 'hype' and a popular method of instruction. Some of the key motivations for implementing flipped classroom are to improve student participation and performance. Our study proved that flipped classroom improved student participation. However, there are conflicting claims regarding the ability of flipped classroom to improve student performance. Some scholars found that students in flipped classroom significantly outperformed their peers in traditional classroom. Others found equal or no significant difference in performance between students in flipped and traditional classroom. Yet there are scholars, just like us, who found that students in traditional classroom outperformed their peers in flipped classroom. The reason for these variations in findings could be the varying nature of the experimental objects: different institutions; different types of students with different learning styles and other learning characteristics; different instructional methods; different courses; different instructors; and so on.

Instructors who implement or plan to adopt flipped pedagogy as a method of instruction should take into consideration that students are more likely to perform less when they are required to allocate time to watching video lectures outside of class as opposed to allocating time to homework. This is because in most cases, students may want to focus on only one activity at a time instead of videos and homework.

Students completing only homework outside the classroom may have more time to consult additional resources and seek tutorials from peers than those completing homework and watching videos. Hence, homework intended for students in flipped classroom should design bearing in mind the grade allocation and assignments. In addition, instructors should closely track homework completion, particularly for flipped students, throughout the course. Furthermore, practitioners should be aware that flipped classroom may not be a magical solution for improving student grade.

Our future work will focus on conducting experiment with two control groups and exact experimental objects to confirm the exact impact of flipped pedagogy on student performance. We intend to directly trace the examination questions to projects and/or homework. More so, we also plan to consider the impact instructional methods on the student performance in flipped pedagogy.

## REFERENCES


[1] B. S. Bell and S. W. Kozlowski, "Active learning: effects of core training design elements on self-regulatory processes, learning, and adaptability." *Journal of Applied psychology*, vol. 93, no. 2, p. 296, 2008. [Online]. Available: http://tinyurl.com/k2bqjtk

[2] M. Prince, "Does active learning work? a review of the research," *Journal of engineering education*, vol. 93, no. 3, pp. 223–231, 2004. [Online]. Available: http://tinyurl.com/ocfqcqj

[3] A. Amresh, A. R. Carberry, and J. Femiani, "Evaluating the effectiveness of flipped classrooms for teaching cs1," in *2013 IEEE Frontiers in Education Conference (FIE)*, Oct 2013, pp. 733–735.

[4] G. S. Mason, T. R. Shuman, and K. E. Cook, "Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course," *IEEE Transactions on Education*, vol. 56, no. 4, pp. 430–435, Nov 2013.

[5] W. T. Tarimo and T. J. Hickey, "Fully integrating remote students into a traditional classroom using live-streaming and teachback," in *2016 IEEE Frontiers in Education Conference (FIE)*, Oct 2016, pp. 1–8.

[6] J. Bergmann and A. Sams, *Flip your classroom: Reach every student in every class every day*. International Society for Technology in Education, 2012. [Online]. Available: http://tinyurl.com/k74vsx5

[7] J. Bergmann, J. Overmyer, and B. Wilie, "The flipped class: Myths vs. reality," *The Daily Riff*, vol. 1, no. 4, 2011. [Online]. Available: http://tinyurl.com/mpvu4n8

[8] K. Fulton, "Upside down and inside out: Flip your classroom to improve student learning." *Learning & Leading with Technology*, vol. 39, no. 8, pp. 12–17, 2012. [Online]. Available: http://files.eric.ed.gov/fulltext/EJ982840.pdf

[9] B. B. Stone, "Flip your classroom to increase active learning and student engagement," in *Proceedings from 28th Annual Conference on Distance Teaching & Learning, Madison, Wisconsin, USA*, 2012. [Online]. Available: http://tinyurl.com/m9r4gmr

[10] M. J. Lage, G. J. Platt, and M. Treglia, "Inverting the classroom: A gateway to creating an inclusive learning environment," *The Journal of Economic Education*, vol. 31, no. 1, pp. 30–43, 2000. [Online]. Available: http://tinyurl.com/l6nbyyg

[11] J. Foertsch, G. Moses, J. Strikwerda, and M. Litzkow, "Reversing the lecture / homework paradigm using eteach web-based streaming video software," *Journal of Engineering Education*, vol. 91, no. 3, p. 267, 07 2002, copyright - Copyright American Society for Engineering Education Jul 2002; Last updated - 2014-05-10; CODEN - JEEDEQ. [Online]. Available: http://tinyurl.com/jwab7mq

[12] A. Roehl, S. L. Reddy, and G. J. Shannon, "The flipped classroom: An opportunity to engage millennial students through active learning," *Journal of Family and Consumer Sciences*, vol. 105, no. 2, p. 44, 2013. [Online]. Available: http://tinyurl.com/mrukllz

[13] A. G. de Oliveira Fassbinder, D. Moreira, G. Cruz, and E. F. Barbosa, "Tools for the flipped classroom model: An experiment in teacher education," in *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, Oct 2014, pp. 1–8.

[14] M. Bradford, C. Muntean, and P. Pathak, "An analysis of flip-classroom pedagogy in first year undergraduate mathematics for computing," in *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, Oct 2014, pp. 1–5.

[15] L. B. Ziegelmeier and C. M. Topaz, "Flipped calculus: A study of student performance and perceptions," *PRIMUS*, vol. 25, no. 9-10, pp. 847–860, 2015. [Online]. Available: http://dx.doi.org/10.1080/10511970.2015.1031305

[16] J. Moffett and A. C. Mill, "Evaluation of the flipped classroom approach in a veterinary professional skills course," *Advances in medical education and practice*, vol. 5, p. 415, 2014. [Online]. Available: http://pubmedcentralcanada.ca/pmcc/articles/PMC4235505/

[17] J. DeSantis, R. Van Curen, J. Putsch, and J. Metzger, "Do students learn more from a flip? an exploration of the efficacy of flipped and traditional lessons," *Journal of Interactive Learning Research*, vol. 26, no. 1, pp. 39–63, 2015.

[18] R. M. Felder, L. K. Silverman *et al.*, "Learning and teaching styles in engineering education," *Engineering education*, vol. 78, no. 7, pp. 674–681, 1988. [Online]. Available: http://tinyurl.com/k2zza92