Effectiveness of Flipped Learning versus Traditional Learning in a Middle-School Chemistry Classroom

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Abstract: Flipped classroom learning methods have been gaining a lot of popularity in recent years. Educators have recorded many mixed results about the effectiveness of this method to achieve superior concept retention in students. Although there has been lot of research published about flipped learning, very little is known how this method affects the learning of Chemistry among middle school students. This study was conducted in two Science classrooms with 3 blocks each over a period of three consecutive days. A total of 122 students took part in this study where 75 students were taught using flipped learning approach whereas 47 students were exposed to traditional method. The students were given pre-test one day before the lesson and taught the next day using the respective teaching methods followed with a post-test on the third day. Findings demonstrate that the average post-test scores for students in flipped learning were higher as compared to traditional method. Additionally, at the end of the study, the students with flipped learning shared their perceptions about the approach.

Keywords: Flipped classroom, Chemistry, Middle School

Introduction

With the ongoing rapid advancements in technology, educators understand the need to incorporate digital technologies into the classroom. Such advancements could not only help generation Z to better engage with their learning content, but also go a step further to create a learning environment that is more student-centered. One of the recent advancements is the flipped learning method which has proven to be impactful in teaching. This approach promotes collaboration by flipping the traditional instruction where the content is delivered outside the classroom in the individual space using technology (online), whereas the group space (classroom) is used for hands-on learning (Winter, 2018).

Recent years have seen a rapid increase in students seeking online education because online learning provides a

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lot of benefits including the ease with which it can be completed while serving different kinds of learners (Allen & Seaman, 2013). This has made learning possible in every situation where the learner can be equipped to take classes at any geographical location at their own convenient pace and time. Such learning opportunities have opened doors for people for whom it was otherwise not possible to gain higher education. An online education basically utilizes online flipped learning methodology where lecturing primarily takes place by watching a video on the lesson content followed by online discussion and assignments.

As the name suggests Flipped Teaching is also famously known as flipped classroom, upside-down teaching, inverted instruction, and backward class. This model shifts the teacher's role as a facilitator and the students become in-charge of their learning (Bergmann & Sams, 2012). In this student-centered instruction, learners first complete the lesson content prior to attending the class by watching videos, completing guided notes, doing online exercises and quizzes. Next the students come in-class and get the opportunity to apply and extend their learning by participating in hands-on projects, classroom discussions, small group activities, and student presentations.

In the flipped learning classroom, students actively participate in the learning process and become responsible for their own learning. Moreover, as there is not much traditional lecturing taking place, there is more class time for teachers to conduct problem solving and higher order learning activities to challenge strong learners whereas provide individualized learning support to weaker students (Kim, Kim, Khera, & Getman, 2014). Thus, this method additionally provides a way to differentiate learning, therefore increasing the overall learning opportunities for each child in the same classroom.

The effectiveness of flipped learning is a topic of continuous investigation in literature. Lo and Hew (2017) provided the literature overview of flipped classroom studies through the analytical lens of "six thinking hats" model that highlights 6 directions - information (white hat), feelings (red hat), thinking about thought (blue hat), creative (green hat), challenges (black hat), constructive (yellow hat). This study also proposes a set of guidelines to address the various challenges reported by other research studies. As part of future research, authors suggest utilizing a pre-test to evaluate the initial equivalence among groups and to investigate consecutive uses of flipped classroom approach with a longer time frame.

Smallhorn (2017) performed a comparative quantitative analysis on the flipped classroom on second year college students where biology lectures were replaced with short online videos and pre-class readings and quizzes. The impact of this approach was analyzed through surveys, attendance records, learning analytics, and exam data. It was found that though this model took some time to gain popularity amongst students, it eventually encouraged them to apply what they had learnt, challenged their understanding of the material, and gave them a forum to ask questions to peers and educators. However, the results showed no measurable impact on academic gains as the exam scores and topic scores for both the traditional and flipped cohorts were very similar. Islam et al. (2018) present a quantitative study to assess and compare students learning outcomes in

college level dental science students. The study was a case control design that took 50 first-year students divided into small groups of 25, each to form, an experimental group (flipped learning model) and control group (traditional learning method). Although students scored higher marks by the flipped learning method there was no significant difference observed between the two methods. However, students expressed their positive perception which reflects their acceptance of this method.

Jdaitawi (2020) utilized a quantitative comparative study between traditional and flipped classroom approaches by analyzing their effects on 65 college students enrolled in science course and found that flipped classroom approach helped students' active learning and enjoyment of the course. However, due to the focus on college students, such results could not be generalized for a larger population. Shyr and Chen (2018) conducted a qualitative analysis to examine whether technology enhanced flipped language learning system could enhance college students' self-regulatory skills. This study was conducted over 9 weeks in which 81 sophomore non-English major students in a required Applied English course are divided into 2 groups of traditional learning and flipped learning. Results showed flipped system offered more effective and engaging learning environment as compared to the conventional flipped classroom.

Other researchers have also investigated the effectiveness of flipped learning method on school students. Sojayapan and Khlaisang (2020) utilizes a quantitative approach to examine the effects of flipped classroom on 30 students studying in upper secondary school. Their results showed that flipped classroom model with videos followed by online group investigation allowed students to carry out different activities as a team and help establish a sense of responsibility for learning while achieving their individual learning goals. Winter (2018) conducted a quantitative analysis to investigate a middle school classroom focusing on a 6th grade social studies course at a K-12 private school in Hawaii, to identify the relationship between student motivation and performance in a flipped learning course. The paper contends that at high school level, online learning studies have shown correlation between performance and self-efficacy, whereas at the middle school level where learning differences are profound, motivation and engagement have shown to increase within technology-supported learning environments.

Thus, although there are many works in literature focusing on flipped learning, the research in middle school children is limited. There has also not been an investigation of flipped learning in middle school Chemistry classes. This paper is a quantitative and qualitative study into the effects of flipped learning on middle school Chemistry classes. The following sections lay out the specific research questions and methodology carried out in this research followed by the findings and implications of this work.

Research Questions

The aim of this study was to compare the students' achievement outcomes in Eighth grade Chemistry class through flipped learning model and traditional lecture model. All students completed a multiple-choice pre-test

and post-test. Additionally, students in flipped learning model were also asked to take survey at the end that reflected their views about the learning model. After analyzing the above literature, following research questions were defined:

- RQ1: Does the implementation of the FCM in middle school Chemistry course lead to improved students' cognitive learning outcomes as compared to a traditional learning model?
- RQ2: Do students feel positive about their learning through FCM?

Method

Participants

The participants included 122 students from two classes studying eighth-grade Chemistry in a public middle school situated in northwestern Pennsylvania. Each class consisted of three blocks of students. The students were divided into 2 groups – control group and experimental group as shown in Figure 1. The control group (block 3 from both classes), including 47 students, learned through face-to-face lectures from teacher that lasted for a majority of time followed by a post-test. On the other hand, the experimental group, consisting 75 students (blocks 1&2 from both classes), learned through video-based lectures that were completed out-of-school followed by active in-class learning activities in the form of tactile projects, demonstrations, and discussions followed by a post-test.

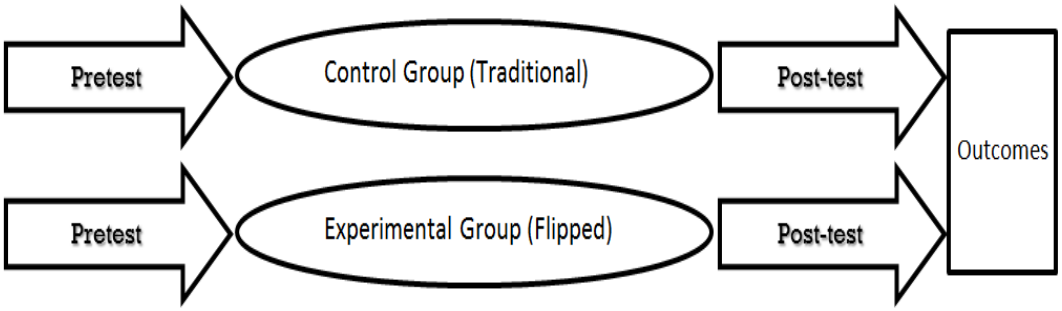

Figure 1. Control Group and Experimental Group

Design Method

A quasi-experimental quantitative study was conducted to evaluate the effectiveness of traditional versus flipped learning for above mentioned middle-school Chemistry course. The curriculum was taught by a student-teacher who was supervised by two experienced teachers in their own classrooms. The students participating in the study were anonymous and allowed to quit at any time (by removing their corresponding data). Both classroom lectures ran in three-block schedules. This study was conducted over a period of 3 days on a single topic for about 80 minutes through both the learning methods in block schedules. Blocks 1 and 2 in both the classrooms were taught using flipped learning whereas block 3 in both classrooms learned using traditional method as shown in Figure 2. All the students were taught the same topic through the same progression of concepts.

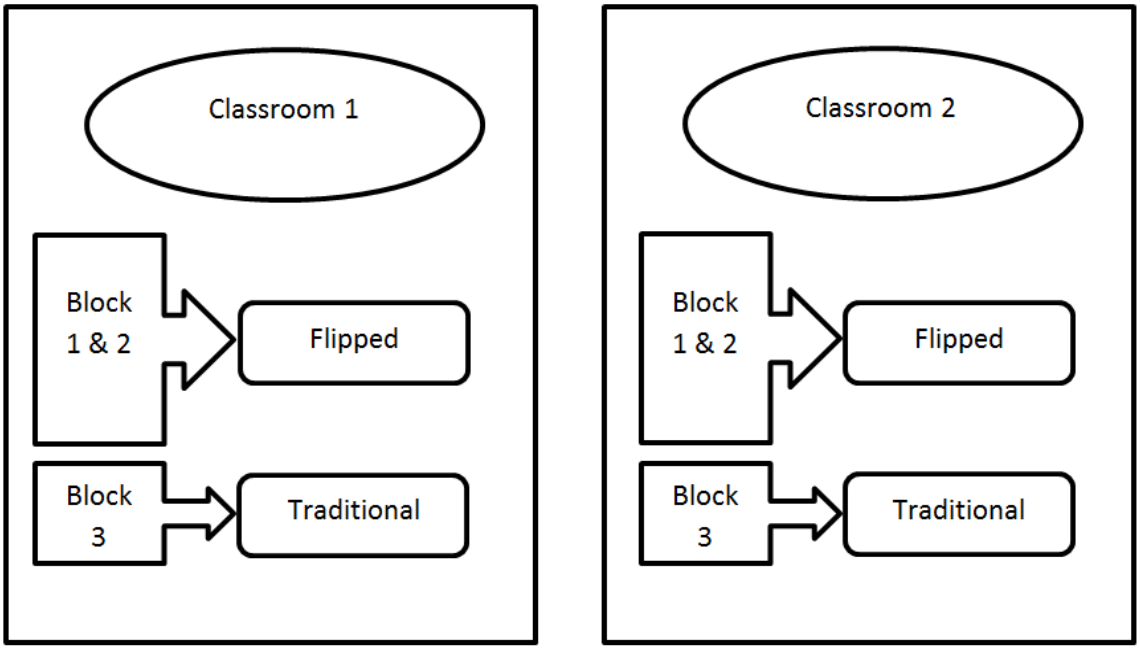

Figure 2. Block Chart of Classroom Grouping

Procedure

On the first day, students in all the blocks gave a pre-test that included 10 multiple choice questions on the school's learning management system called *Schoology* and the students were given a brief overview of the experiment to be conducted over the next two days. On the same day, students in flipped classroom model (blocks 1&2) filled a flipped classroom readiness survey. They were asked to watch teacher prepared videos that lasted for not more than 15 minutes after school. The videos included teacher explaining concepts, short clippings showing demonstrations and talks from other experts. Students were required to watch this lecture video prior to coming to the class. Students were given a day to watch the videos (multiple times if the student desired) and expected to fill the skeletal note sheet for that lecture video and submit to the student-teacher. The skeletal notes helped the student-teacher know which students had watched the video and segregate students into three stations. The first station consisted of students that had not completed the at home assignments (watching the videos and filling the skeletal notes). The second station consisted of students who had done the work but had scored below a threshold on the skeletal notes. The third station consisted of students who had both done the work and scored above the threshold on the skeletal notes. The skeletal notes also served as lecture notes that helped students to carry out discussions in-class and for any future reference.

On the second day, students in traditional classroom model, block 3 for both classes were combined and attended face-to-face instruction from the student-teacher. The lecture was teacher-centered for the maximum part for a total period of 80 minutes wherein the student-teacher explained the concepts and students asked questions. All the students of the traditional method were given homework and asked to submit it the following

day. On the same day, the students in flipped classroom model, blocks 1&2 from both classrooms were combined and directed to work at the three different stations of the classroom. Through this differentiated learning approach, the student-teacher was able to devote time in tune with the needs of the three stations. Additionally, the student-teacher could also use this learning space to individually help and personalize instruction to struggling students who needed more help. All flipped model students could actively participate in reinforcement activities that included small group discussions, role-play, presentations, etc. During this student-centered learning activity time, the student-teacher acted as facilitator and guided students' learning by scaffolding instruction whenever necessary. The same assignments that students completed as homework in traditional classrooms were given to students in flipped classroom model. The only difference was that students in flipped classroom model completed them during the class time by engaging themselves in various hands-on learning activities independently and/or in groups as preferred by the students.

On the third day, students in both flipped and traditional model were given the same post-test to evaluate their understanding. All the test questions were aligned with state science standards and had content-related validity. Additionally, only the students in flipped classroom model took part in a survey that contained multiple choice questions and few open-ended questions that asked them about their perceptions on the model. The survey consisted of 6 multiple choice questions and 4 short-type questions. At the end, the results of the performance of all the blocks on the post-test were also shared with all students to get more student involvement in this method for future classes.

Results

The study collected data from all 122 students and conducted an analysis using Excel spreadsheet. The data was collected from all the students (blocks 1, 2 & 3) of the two different classes that were given pre-test and post-test. As seen from Table 1 below, the percentage increase in students' scores were calculated based on the average pre-test and post-test scores. Results showed a higher percentage increase scores of students in blocks 1 and 2 who were taught using the flipped learning methodology as compared to block 3 students who learned through traditional approach.

Table 1. Percentage Increase in Student Scores (Block1/Block 2: Flipped, Block 3: Traditional)

Classes	Average Pre-test	Average Post-test	Percentage Increase in Student Scores
Classroom 1 Block 1	7.40	8.73	18.02%
Classroom 1 Block 2	6.22	8.83	41.96%
Classroom 1 Block 3	8.04	8.50	5.70%
Classroom 2 Block 1	6.30	8.30	31.75%
Classroom 2 Block 2	7.10	9.10	28.17%
Classroom 2 Block 3	7.39	7.91	7.06%

Table 2 below shows an excerpt which is representative of what students felt in general about the flipped classroom model. Each line represents a response from a different student.

Table 2. Student Perceptions

Student Comments
"The freedom"
"I liked the activities we did because it's more engaging"
"I can do the work at my own pace"
"That I was learning in a fun way"
"I enjoyed the Flipped Classroom and thought it was both engaging and educational"
"I do not like the flipped classroom, but it can be more fun not having to rush through the lesson"
"I liked the fact that it made the work easier because I could understand better"
"I liked to communicate with people in the class that I don't really talk to"
"I cannot ask a teacher if I don't understand something"
"I liked that we were able to have more fun in the classroom"
"I like how we got to engage with other students"
"I liked how we can do things on our own time and pace"
"Sometimes it can get hard and students might get confused"
"That when you come to school you can do more practice"
"I could sit in my bed and learn from home"
"I liked how we were able to do it at our own pace"

Discussion

Figure 3 shows the comparison of average pre-test and post-test scores between all the 6 blocks from both classes. From the results it can be concluded that the learning methodology does have a lot of impact on student learning and their scores. Blocks that were taught using the flipped model learned more effectively and performed better on their post-test as compared to their pre-test. There was more increase seen in the post-test scores as compared to their pre-test scores for blocks 1 and blocks 2. On the contrary, block 3 in both classes did not show much increase in their pre-test to post-test scores that shows that the learning methodology in block 3 was not as effective as the learning methodology in blocks 1 and blocks 2.

Figure 4 shows the graphical line plot of the percentage increase in student scores. The combined four blocks that have received flipped learning approach show uneven increments in the improvements seen through this approach accounting for the difference in makeup of the students. It can be satisfactorily inferred that flipped learning approach in block 1 and block 2 results in a significantly higher positive spike in student scores as compared to block 3 that received instruction using traditional approach.

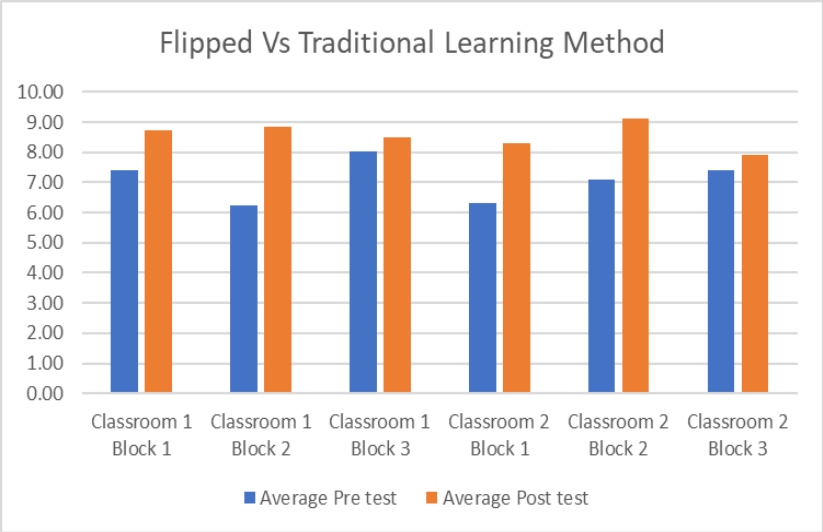

Figure 3. Flipped Versus Traditional Learning Method

As can be inferred from Table 2, the student perceptions about flipped classroom model seemed quite positive and encouraging. From the general feedback, we can conclude that students supported this mode of learning for its convenience, engagement, reinforcement, and retention. There was also some negative feedback from the students regarding teacher's availability, at home time management and content complexity.

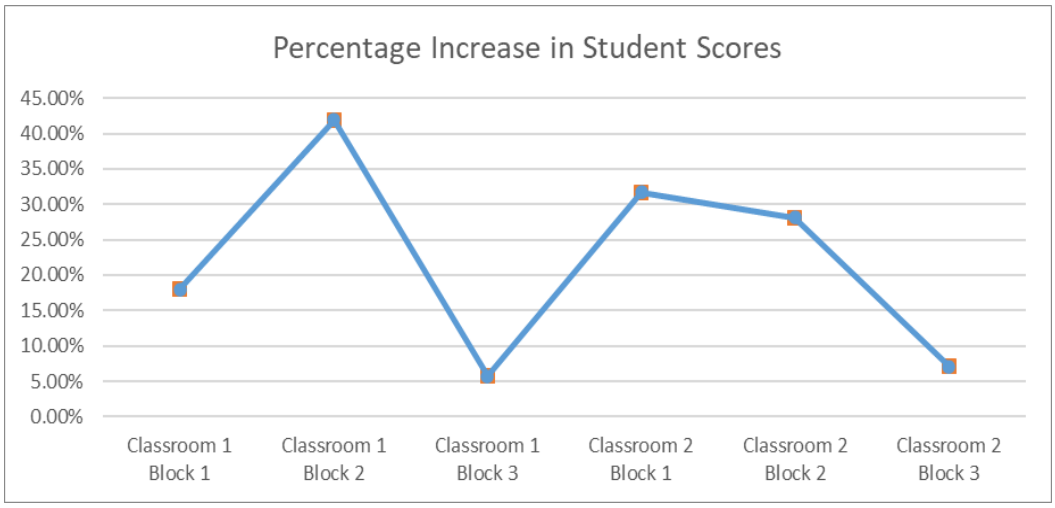

Figure 4. Percentage Increase in Student Scores

Before the post-test was conducted, students in blocks 1 and 2 were encouraged to revise the concepts at home by watching the flipped video and studying the skeletal notes prior to attending class the next day, as compared to students in block 3 who revisited the concepts using homework given to them. The results showed higher learning outcomes for students in flipped classroom. These students got the opportunity to learn better using hands-on activities and revise the concept multiple times at their own convenience by watching their teacher on flipped video prior to the post-test.

Conclusion

The quantitative results of this study revealed how flipped learning model could help increase students' learning outcomes as compared to traditional learning. The qualitative results also indicate that this method is overall well received by students. As generation Z is more inclined towards using technologies, flipped learning method could help kids engage better in their learning and increase their understanding of the content. This method focusses on doing more hands-on learning in the classroom that could further increase student interest leading to more profound grasp of science concepts. As majority of theoretical concepts are covered outside the classroom at least once, the concepts get more reinforced when students do additional work on important concepts within the classroom through discussion and teamwork. Moreover, flipped learning methodology can also prove effective in differentiating instruction as teachers could have more in-class time available that could be used to provide individualized learning to kids whose need more time to grasp concepts and more personalized instruction. Thus, we can conclude that the implementation of flipped classroom model in eighth grade Chemistry could lead to improved cognitive learning outcomes in students as compared to in traditional learning model.

Recommendations

The results of this study could not be generalized as it is conducted over a shorter time duration. Future studies could consider implementing a similar study on a longer time frame. A longer study could offer the opportunity to test the effectiveness of flipped learning on multiple lessons with varying degree of complexity for the same set of students. Further research could also be conducted to find if there was any difference by gender in the reception of flipped learning. This study also considers participants from only the eighth grade. If future studies could widen their scope to include students from all grade levels in middle school, it will lead to more insights on how and when flipped learning will be an effective teaching strategy.

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