Flipped Classroom as an Alternative Strategy for Teaching Stoichiometry

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Abstract– *This study aimed to compare the effectiveness of flipped classroom and traditional classroom instruction in measuring conceptual change and to determine if flipped classroom instruction would be an alternative method of teaching to traditional lecture method. This study covered the level of conceptual understanding of students on stoichiometry and the type of conceptual change before and after exposure to flipped and traditional classroom environment. Qualitative and quantitative research methods were used in the study. Respondents were two sections of third year Bachelor of Secondary Education, Biological Science. Frequency, percentage, ranking, mean, standard deviation, Hake factor test, and t-test were the statistical tools applied to answer specific questions. Results showed profound increase towards conceptual change representing a shift from intuitive understanding to correct incomplete understanding level. Thus, change for the better, in theoretical type was determined from pretest to posttest of students exposed to flipped and traditional classroom. Results also indicated that there is no significant difference on students' conceptual change on stoichiometry exposed to flipped and traditional classroom environment thus, flipped classroom instruction can be used as an alternative teaching method to traditional lecture method in teaching stoichiometry.*

Keywords: *conceptual change, flipped classroom, stoichiometry, traditional classroom*

INTRODUCTION

Science teaching should be imparted in such a manner that a positive kind of change can take place to the students. That after attaining information relating to scientific facts and theories, students conceptions become more rational and logical [1].Science teachers are responsible for preparing students to become scientifically literate individuals. They must be aware on how students move from their prior knowledge to scientifically acceptable ideas. They need to provide students with opportunities to recognize what prior knowledge they already possess, expand on their incomplete schema, and confront inaccurate prior knowledge.Conceptual change theorists recognize that there exists a conceptual framework in the minds of the students that needs to be changed. The heart of all conceptual change strategies is the knowledge-restructuring component of prior conceptions [2].

From the concepts of Allison and Barret [3] constructivist teaching represents a change from the current traditional view of how teachers teach and learners learn. Traditionalists see the teacher as the keeper of all knowledge, the teaching process as one of transmitting knowledge from teacher to learner, and learners absorbing what the teacher has to offer. Constructivists see both teachers and students as active in developing knowledge. They work together in the teaching-learning process to make their educational experiences relevant and meaningful. Students are not expected to repeat what the teacher says, instead they are expected to explore, elaborate, and demonstrate their understanding of the subject matter being taught.

According to Martin and Loomis [4] the role of constructivist teachers is to facilitate learning and to provide a variety of learning experiences that enable each student to learn in his or her own unique way and to construct the information such that it makes sense to the individual. Constructivist teachers ask students their conclusions and their explanations rather than repetitions of what the teacher presented. To constructivist teachers, it is far more important to listen than to tell.

Constructivist teachers are able to relinquish control of student learning. They trust their students to be responsible for their own learning. They allow students' interest to drive the lessons and let the students make intellectual choices for themselves [5]. Teachers who use a constructivist theory see each individual as the maker of his or her own knowledge [6].

In today's technologically oriented environment, there are growing concerns to shift from traditional method to innovative method of teaching and learning. Pedagogical innovations demand students to take ownership of their learning and construct knowledge as they interact with the dynamic environment.The need for a continuous search for teaching methods and approaches that will provide more relevant and meaningful learning is a must in educational sector.Therefore, teachers must accurately assess students' knowledge and identify the effective and innovative learning strategies that may be utilized in improving it.

Science teachers should be encouraged to provide the students with variety of learning activities and innovative strategies to enhance the mastery of students' skills and knowledge. Science educators must reassess their teaching practices. They must look for alternative and better strategies that will be effective in measuring conceptual change.

In spite of efforts exerted by science educators to strengthen conceptual understanding of scientific concepts, some still fail to apply new instructional strategies that scaffold learners.Still some educators embrace the use of traditional method. The needed shift is from a teacher-centered classroom to a student-centered learning environment. From this aspect, flipped classroom can be viewed as conceptual change and constructivist teaching approach that effectively provides learning environment in which students use actively their knowledge, construct their views about science, and develop critical thinking. It creates learning environment that provides students opportunities to change their incorrect conceptions to scientific conceptions [7].

In a traditional lecture, students often try to capture what is being said at the instant the speaker says it. They cannot stop to reflect upon what is being said, and they may miss significant points because they are trying to transcribe the instructor's words. By contrast, the use of video and other prerecorded media puts lectures under the control of the students, they can watch, rewind, and fast-forward as needed. In inverted learning, students can absorb the material as homework and then practice what they learned with guided help from the teacher if they need it. This new learning style not only makes class time more productive for both teachers and students, but also increases student engagement, increases achievement, and caters to all forms of personalized learning.

In the article of de Haan [8] several advantages to this model of teaching were presented. In flipped teaching an educator doesn't need to guess at what speed to deliver content – with students watching lectures at home they can move at their own speed and review concepts as necessary and without large portions of classroom time spent lecturing. Educators can use class time to see students working through assignments and problem sets. According to Gerstein [9] the implementation of flipped classroom instruction paved way for a better learning. In this kind of instruction the content, often the theoretical/lecture-based component of the lesson, becomes more-easily accessed and controlled by the learner.

The flipped classroom constitutes a role change for instructors, who give up their front-of-the-class position in favor of a more collaborative and cooperative contribution to the teaching process. The instructor acts as a facilitator to motivate, guide, and give feedback on students' performance [10]. Hence, by applying the flipped classroom approach to teaching and learning activities, the instructor can move the traditional lecturer's talk to video and the students can listen to the lectures anywhere outside of class. The flipped classroom allows students to watch the video according to their preferred time and need, and they can study at their own pace; this type of activity also increases students' collaborative learning in distance education outside the class. Thus, by flipping the class, the students will not spend so much time listening to long lectures in the classroom, but will have more time to solve problems individually or collaboratively through distance learning with peers.

Flipped classroom is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions [11]. Flipped classroom instruction facilitates the transformation of the pre-existing incorrect knowledge to scientific one. The idea of flipping the classroom to make class time more engaging and student-centered has gained ground on conceptual change. Flipped classroom teaching method seems to be effective in creating conceptual change since in-class time is meant for exploring topics in greater depth and creating richer learning opportunities.

Alcantara [12] in his study determined the effect of flip-flop teaching in the performance of engineering students in Introductory Physics, particularly, in fluid mechanics. His study revealed that the variation in the performances of the students in the conceptual questions, in the problem solving questions, and overall performance in fluid mechanics when grouped according to the types of instruction were not significantly different. Engineering students taught in a traditional Physics classroom, in an inverted Physics classroom, and in an enhanced-inverted Physics classroom were more likely to have similar performances in fluid mechanics.

One concern about the flipped classroom that has been recently posed is that flipping is compatible with an inquiry approach to teaching science. Flipping a science class creates more time and more opportunities to include inquiry learning. Science teachers who flip have time for students to engage in more inquiry-based activities and to conduct more in-depth experiments. In the Chemistry education, it has become a powerful tool for students to create conceptual understanding without direct instruction [10].Chemistry is one of the science subjects that students must have a good level of understanding. According to Wolf and Chan choosing a unit that the students find challenging is usually best-suited for flipping. Stoichiometry is one of the challenging topic in chemistry courses. Stoichiometry covers the quantitative relationships between the amount of reactants and product in a chemical reaction. It consists of many abstract concepts that can be incorrectly interpreted and learned by the students. Introducing flipped classroom instruction in Chemistry topics will be meaningful and functional for students.

In the light of the foregoing theories and concepts, these expound that teaching-learning process is expected to bring about a change in students' learning approach and conceptual understanding. It further expounds that effective teaching is not purely a transfer of knowledge from teacher to the learners. It is not merely monitoring or checking what the teacher has taught to them or dictated to them. Effective teaching requires that the teacher becomes a fully functioning person so that he/she is able to create a meaningful and effective teaching environment that enables the learners to grow and be responsible for their own learning. Likewise, teachers' instructional strategies must create opportunities that challenge students and promote critical thinking.

Thus, to address this concerns, this research attempted to compare the effectiveness of flipped classroom and traditional classroom instruction in measuring conceptual change. This study also determined if flipped classroom instruction would be an alternative method of teaching to traditional lecture method. The potential of flipped classroom instruction to navigate conceptual change prompted the researcher to undertake this study. This study then was conducted to respond to the challenge of a continuous search for a more meaningful and relevant science learning strategies which could benefit both students and teachers.

OBJECTIVES OF THE STUDY

This study aimed to compare effectiveness of flipped classroom instruction andtraditional classroom instruction in measuring conceptual change among Bachelor of Secondary Education (BSED) major in Biological Science students. It investigated if flipped classroom instruction would be an alternative method of teaching to traditional lecture method. This sought to determine the level of conceptual understanding of the students on stoichiometry exposed to flipped classroom and traditional lecture method prior and after the instruction; classify the type of conceptual change as determined from pretest to posttest of students into unchanged conception, change for the better (extension of field of applicability, semantic conceptual change, and theoretical conceptual change), and regression; and find significant difference on the students' conceptual change exposed to flipped classroom instruction and traditional lecture method.

METHODS

This study used both qualitative and quantitative research methods. The qualitative part involved the analysis of the students' explanations in the Conceptual Understanding Test. The quantitative part was collected from the pretest and posttest results on some selected topics in stoichiometry. Aside from the Conceptual Understanding Test interviews was also used as a source of data.

In this study, purposive sampling technique was used in selecting the participants. The researcher chose the sample based on the criteria appropriate for the study. In this case, participants were two sections of third year BSED Science major students enrolled in Sci-306 (Inorganic Chemistry). Section 1 consisting of 20 students were exposed to flipped classroom instruction. Section 2 consisting of 30 students were exposed to traditional method. All the students involved were made aware of the purpose of the study to be conducted, after which the orientation informed consent form was given to all the participants to ensure that their participation would be voluntary.

Pretest was administered before the exposure of the students in a flipped classroom and traditional classroom instruction to determine the students' level of conceptual understanding. Students' understanding was categorized into five levels: best understanding, correct incomplete understanding, partial understanding, functional misconception and intuitive understanding. Each item was scored following the rubric shown in Table 1.

Table 1. Rubric in Scoring Students' Responses in Conceptual Understanding Test

Category	Answer	Explanation	Equivalent Points
Best Understanding (BU)	Correct	Complete correct explanation	4
Correct Incomplete Understanding (CI)	Correct	Correct only incomplete lacking some details	3
Partial Understanding (PU)	Correct or wrong	Explanation is partly correct but part of it is also wrong	2
Functional Misconception (FM)	Correct or wrong	Wrong explanation	1
Intuitive Understanding (IU)	Correct or wrong	No explanation and if there is, only repeats the statement of the choice or the stem	0

Three college Chemistry Professors, including the researcher, rated the students' answer in the pretest and posttest. The ratings given by the three interraters were subjected to nonparametric statistical analysis using Kendall's coefficient of concordance, W. Statistical analysis showed that there was an agreement among the three interraters. Pretest results and respondents' grades in Math and Science in the previous semester were analyzed and subjected to statistical analysis to establish the comparability of the two groups of respondents before subjecting them in the actual instruction. Statistical analysis showed that there was no significant difference between the experimental and the control group as indicated by the p-value which is less than 0.05. The average mean of the scores given by the three interraters for each item were computed and were coded following Table 2.

Table 2. Rubric in Converting Mean Score to Category of Understanding

Mean Score	Code
3.50 – 4.00	BU
2.50 – 3.49	CI
1.50 – 2.49	PU
0.50 – 1.49	FM
0 – 0.49	IU

During the flipped classroom teaching, lessons on stoichiometry were studied by the students at home using the developed video-taped lectures prepared by the researcher.There are three selected topics on stoichiometry that were covered in the instruction, namely, chemical reactions, mass relationships from balanced chemical equations, and limiting reactants. During the face-to-face classroom setting, students were given exercises and problem sets to encourage students to reflect on the concepts they learned and to evaluate their learning. During the traditional classroom teaching there were lessons parallel to the flipped classroom instruction. Discussions of the lessons were done inside the classroom. Presentation of the lesson was done through lecture followed by exercises, problem sets, and assignments.

The Conceptual Understanding Test was administered again after the completion of instructional process. Students' new conceptions and new levels of conceptual understanding were determined using the test. Oral interview was conducted to selected students to clarify their answer and explanations to some of the items in the Conceptual Understanding Test. Each posttest item response was also categorized into five levels of conceptual understanding, the same as what was done in the pretest.

The category of conceptions for each item in the pretest and posttest was compared to determine if the instructional process brought about improvement, regression or unchanged students' conceptions. Table 3 presents the criteria for the different classification of conceptual change.

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Table 3. Criteria for Classifying Students' Conceptual Change

Category of Conceptual Change	Criteria
Unchanged Conception	Student remained in any of the following: BU, CI, PU, FM or IU
Change for the Better a) extension of field of applicability b) semantic conceptual change c) theoretical conceptual change	Change which occurred in: a) IU to FM b) PU to CI; FM to CI; FM to PU; or IU to PU c) CI to BU; PU to BU; FM to BU; IU to BU; or IU to CI
Regression	Change which may be any of the following: BU to CI; BU to PU; BU to FM; BU to PU; CI to FM; CI to IU; PU to FM;PU to IU, or FM to IU

Results of the pretest and posttest Conceptual Understanding Test on Stoichiometry, provided the data which were subsequently analyzed using the Hake factor test (normalized gain). It was used to measure the effectiveness of flipped classroom and traditional classroom instructionin promoting conceptual understanding. Pretest and posttest results were also used to determine if there is significant difference on the students' conceptual understanding of stoichiometry exposed flipped classroom instruction and those exposed to traditional lecture method. Descriptive equivalents and verbal description for Hake Factor Test results were presented in Table 4.

Table 4. Descriptive Equivalents for the Hake Factor Test Results

Formula	Scale Range	Verbal Description
$h = \frac{post - pre}{1 - pre}$	0.71 – 1.00	High gain
	0.31 – 0.70	Medium gain
	0.10 – 0.30	Low gain

RESULT AND DISCUSSION

Level of Conceptual Understanding of the Students on Stoichiometry Exposed to Flipped Classroom and Traditional Lecture Method Prior and After Instruction

To establish the level of understanding of the students on stoichiometry exposed to flipped and traditional instruction, frequency distribution of students' level of understanding is presented in Table 5. As shown in the table, prior to instructions, 15 (75%) of the participants under flipped classroom instruction and 26 (86.67%) under traditional lecture method were in the intuitive level of understanding. Five (25%) of the participants under flipped and 4 (13.33%) under traditional were in the functional misconception. Results showed that before the instruction, participants had no enough prior knowledge on stoichiometry.

The table also reveals that 11 (55%) of the participants under flipped classroom and 16 (53.33 %) under traditional attain the complete understanding level; 4 (20 %) under flipped and 10 (33.33%) under traditional attain the best understanding level; and 5 (25 %) under flipped and 4 (13.33 %) under traditional attain the partial understanding level after the instruction. Data show that there is a profound increase in the level of conceptual understanding of the students from lower level in the pretest to higher level of understanding in the posttest. Generally, a shift from intuitive understanding to correct incomplete understanding level is the most evident change among students after the instruction.

Table 5. Frequency Distribution of Students' Level of Conceptual Understanding in the Two Groups of Respondents

Level	Flipped Classroom (n=20)				Traditional Lecture (n = 30)			
	Pretest		Posttest		Pretest		Posttest	
	f	%	f	%	f	%	f	%
BU	0	0.00	4	20.00	0	0.00	10	33.33
CI	0	0.00	11	55.00	0	0.00	16	53.33
PU	0	0.00	5	25.00	0	0.00	4	13.33
FM	5	25.00	0	0.00	4	13.33	0	0.00
IU	15	75.00	0	0.00	26	86.67	0	0.00
Total	20	100	20	100	30	100	30	100

Type of Conceptual Change as Determined from Pretest to Posttest of Students Exposed to Flipped Classroom and Traditional Classroom Instruction.

Reflected from Table 6 that nobody among the participants were classified into unchanged conception and regression category of conceptual change after the flipped classroom and traditional classroom instruction. It is clearly manifested that change for the better (100%) was attained after the exposure of the students to flipped and traditional classroom method.

Table 6. Frequency of Students' Responses Using Conceptual Change Categories

	Flipped Classroom		Traditional Classroom	
Categories	**f**	**%**	**f**	**%**
Unchanged conception	0	0.00	0	0.00
Change for the better	20	100.00	30	100.00
Regression	0	0.00	0	0.00
TOTAL	20	100.00	30	100.00

To further determine the number of students that falls under the change for the better type of conceptual change from pretest to posttest, frequency distribution of students for both group is presented in Table 7.

Table 7. Frequency Distribution of Students in Change for the Better Category in the Two Groups of Respondents

Type of Change	Flipped Classroom (n = 20)		Traditional Classroom (n = 30)	
	f	**%**	**f**	**%**
Extension of Field of Applicability	0	0.00	0	0.00
Semantic	8	40.00	5	16.67
Theoretical	12	60.00	25	83.33
Total	20	100	30	100

As reflected from Table 7, 12 (60.00 %) under the experimental group, and 25 (83.33 %) under the control group fall under the theoretical type of conceptual change; and 8 (40.00 %) under experimental group, and 5 (16.67 %) under control group fall under the semantic category. It is clear from the table that majority of the participants gained the theoretical type of conceptual change after the instruction. It only implies that the students' concepts on stoichiometry after the instruction have become coherent with the scientific principle. Results reveal that flipped classroom, the same as traditional classroom instruction catalyzed better understanding of stoichiometry. It can bring about theoretical conceptual change among students. This finding is in line with Gerstein's view [9] thatthe implementation of flipped classroom instruction paves way for a better learning.

Table 8. Average Normalized Gains for the Two Groups of Respondents

Group	Pretest	Posttest	g	SD	Interpretation
Flipped	0.08	0.74	0.72	0.16	High gain
Traditional	0.07	0.78	0.76	0.14	High gain

Comparison of the Students' Conceptual Change on Stoichiometry Exposed to Flipped Classroom Instruction and Traditional Lecture Method

Table 8 reveals that both the experimental and control group are in the high gain as reflected by the normalized gain values of 0.72 (SD = 0.16) and 0.76 (SD = 0.14). This only means that flipped classroom instruction and traditional lecture method are both effective in developing conceptual change in teaching stoichiometry. To determine if differences in mean gain scores are statistically significant, t-test was performed on the two groups of respondents.

Table 9. Comparison of the Hake Factor Results of the Two Groups of Respondents

Grouping	g	SD	t-value	p-value	Interpretation
Flipped	0.72	0.16	1.031	P = 0.308 > 0.05	NS
Traditional	0.78	0.14			

Table 9 shows that there is no significant difference on the students' conceptual change on stoichiometry between the flipped classroom and traditional classroom instruction, as reflected by the t-value of 1.031 and p-value of 0.308 which is less than 0.05. Thus, the null hypothesis is accepted. It is very evident from the results that flipped classroom instruction is comparable to the traditional lecture method in terms of its effectiveness in fostering conceptual change. Results imply that flipped classroom instruction can be used as an alternative teaching method to traditional classroom in teaching stoichiometry.

CONCLUSION AND RECOMMENDATION

The third year science major Education students have intuitive level of conceptual understanding of stoichiometry before the exposure to flipped classroom and traditional classroom instruction, and a correct incomplete level of understanding after the instruction. A change for the better, in theoretical type of conceptual change is determined from pretest to posttest of students exposed to flipped classroom and traditional lecture method. Students taught in a traditional lecture method, and in a flipped classroom instruction have similar performances. Therefore, flipped classroom instruction is comparable to the traditional lecture method in terms of its effectiveness in fostering conceptual change. Flipped classroom instruction can be used as an alternative teaching method to traditional lecture method in teaching stoichiometry.

Results of the study reflect a constructivist theory that learners actively construct their own understanding of information and see each individual as the maker of his or her own knowledge. In a flipped classroom strategy teachers are able to relinquish control of student learning and the students become responsible for their own learning.

Implication of these findings emphasize that flipped classroom constitutes a role change for instructors, who give up their front-of-the-class position in favor of a more collaborative and cooperative contribution to the teaching process. Thus, by flipping the class, the students will not spend so much time listening to long lectures in the classroom, but will have more time to solve problems individually or collaboratively and use various technology media in learning activities independently.

Student response to the flipped classroom instruction was largely positive, indicating it to be an approach worth pursuing in future years.Thus, it is recommended to continuously measure the effectiveness of flipped classroom instruction on developing conceptual change and be tried out in different disciplines and venues. Since, the study was conducted for one semester to third year science major education students, it is also recommended to lengthen the observation period and consider a greater number of subjects from different degree programs and year levels.

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