Measuring Conceptual Change on Stoichiometry Using Mental Models and Ill-Structured Problems In a Flipped Classroom Environment

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Abstract -*This study aimed to measure conceptual change on stoichiometry using mental models and ill-structured problems in flipped classroom environment. This study examined the level of conceptual understanding of students on stoichiometry before and after exposure to flipped and traditional lecture method. It also covered the type of conceptual change, and students' description in flipped 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 instruction. Results also indicated that there is no significant difference on students' conceptual change on stoichiometry exposed to flipped and traditional lecture method. Furthermore, students strongly agreed that flipped classroom instruction helped them develop positive attitude towards chemistry and appropriate for learning college chemistry.*

Keywords: *conceptual change, flipped classroom instruction, ill-structured problems, mental models, stoichiometry*

INTRODUCTION

Conceptual change is the process of change from the learner's prior conception to scientific conception. An overwhelming body of educational research has documented the considerable difficulties students encounter in this area [1],[2]. These difficulties are not present only in the case of the weaker or younger students. They are present even in the brighter college students attending the most prestigious universities.Scientific misconceptions are reduced when instructional practices provide opportunities to build on student prior knowledge, thus providing students with opportunities to examine conceptions.

The goal of science education is to help students develop a deep understanding of abstract concepts [3].Chemistry is a science that involves many abstract concepts that can be incorrectly interpreted and learned by the students. Science teachers are charged with preparing students to become scientifically literate individuals. They must be aware on how students move from their prior knowledge to scientifically acceptable theories. 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 or misconceptions. Therefore, teachers must accurately assess students' knowledge and identify the effective and innovative learning strategies that may be utilized in improving it. According to Thompson et al. [4] teachers must look into an alternative and better learning theory that is effective in bringing about conceptual understanding. There were situations when difficulties arose in developing the learners' ability to apply concepts in solving problems. Hence, it is essential that students learn in a conceptual manner. Students should continuously be involved in concrete models and be able to express correct solutions to the given problems

[5].Using mental structures allows a child or an adult to create or construct new knowledge or to modify previously constructed knowledge and to modify and construct new structures [6]. When students are encouraged to relate new information to what they already know relevance is established, and learning occurs. This is constructivism. Constructivism view learning as an active process in which the learner uses sensory input and constructs meaning out of it. In the constructivist class setting, prior knowledge is elaborated, modified, or changed on the basis of new meanings brought about by the different activities done. In the process, the learner builds up his own conceptual framework or cognitive schema [7].

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 [8]. Flipped classroom instruction facilitates the transformation of the pre-existing incorrect knowledge to scientific one. 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 provide students opportunities to change their incorrect conceptions to scientific conceptions [9].According to Wolf and Chan a successful flipped classroom requires detailed planning [10]. Teachers are advised to start small and it is unnecessary to flip the entire course from the beginning. Choosing a unit that the students find challenging is usually best-suited for flipping. Stoichiometry is one of the challenging topics 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.

Weaver and Sturtevant [11]looked at quantitative measures of student performance in the flipped versus the traditional lecture approach of Chemistry course. Their study showed that students' General Chemistry exam scores in the flipped class were significantly higher when compared with the students' previous scores in the traditional class. Analysis of open-ended surveys given to students at the end of the course showed that the majority of students responded positively to the flipped classroom.

Shattuck [12] study examined the effectiveness of a partially flipped course in the first semester Organic Chemistry course. Significant improvements in test questions on flipped topics were observed, as well as a significant reduction in the course withdrawal rate.

Schultz et al.'s and Butt[13, 14] study investigated the effects of the flipped classroom on academic performance of Chemistry students. A statistically significant difference was found on all assessments with the flipped class students performing higher on average. In addition, most students had a favorable perception about the flipped classroom noting the ability to pause, rewind, and review lectures, as well as increased individualized learning.

Considering the issues manifested in the teaching of science, the researcher decided to conduct this study of conceptual change. Discovering alternative and better strategies that will be effective in measuring conceptual change may be done to aid students in changing their misconceptions toward scientifically acceptable understanding of phenomena. 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 measure the conceptual change among Bachelor of Secondary Education (BSED) major in Biological Science students. It investigated the effectiveness of flipped classroom instruction on the students' conceptual change. This sought to determine the level of conceptual understanding of the students on stoichiometry using mental models and ill-structured problems 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; find significant difference on the students' conceptual change exposed to flippedclassroom instruction and traditional lecture method; and determine students view on their journey in measuring conceptual change in a flipped classroom environment.

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MATERIALS AND METHOD

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 and interviews, researcher-made questionnaire 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 instruction and traditional method 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 and 2.

Table 1. Rubric in Scoring Students' Responses in Part 1 of the 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

Table 2.Rubric in Scoring Students' Responses in Part 2 of the Conceptual Understanding Test

Category	Multiple Choice	Solution/ Reason to Worded Problem	Ill-Structured Problem	Equivalent Points
Best Understanding (BU)	Correct	Complete correct solution	Complete correct identification of all the missing/ incorrect details	4
Correct Incomplete Understanding (CI)	Correct	Correct incomplete lacking some details	Correct incomplete identification of all the missing/ incorrect details but lacking some information	3
Partial Understanding (PU)	Correct or wrong	Solution is partly correct but part of it is also wrong	Identification of all the missing/ incorrect details is partly correct but part of it is also wrong	2
Functional Misconception (FM)	Correct or wrong	Wrong solution	Wrong identification of all the missing/ incorrect details	1
Intuitive Understanding (IU)	Correct or wrong	No solution	No answer	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 andrespondents' 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 3.

Table 3.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. Discussion of the lessons was 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, and to their descriptions in flipped classroom instruction. 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 4 presents the criteria for the different classification of conceptual change.

Table 4.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	Change which occurred in:
a) extension of field of applicability	a) IU to FM
b) semantic conceptual change	b) PU to CI; FM to CI; FM to PU; or IU to PU
c) theoretical conceptual change	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 instruction in 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 5.

Students' view regarding their journey in a flipped classroom environment was determined through questionnaire. The instrument developed was subjected to content validation by the experts in

Chemistry. A content validity questionnaire was used with specified criteria using a four-point Likert type scale. This assessed the suitability of the test items to the cognitive and vocabulary level of the students and to the learning objectives. This also assessed how adequately the questionnaire can measure students' level of understanding on stoichiometry. Interview prompt was also conducted in order to clarify further students' view on a flipped classroom environment strategy. The score of each questionnaire item was given corresponding weight value presented in Table 6.

Table 5.Descriptive Equivalents for the Hake FactorTest Results

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

Table 6. Descriptive Equivalents for the Students Description on Flipped Classroom Instruction

Options	Scale Range	Verbal Description
4	3.50 – 4.00	Strongly agree
3	2.50 – 3.49	Agree
2	1.50 – 2.49	Disagree
1	1.00 – 1.49	Strongly disagree

RESULTS AND DISCUSSION

Table 7. Level of Conceptual Understanding of the Students Prior to Instruction

Item	Flipped Classroom			Traditional Lecture		
	Mean	SD	Level	Mean	SD	Level
Mental Model						
1	0.80	0.41	FM	1.29	0.69	FM
2	0.63	0.49	FM	0.40	0.52	IU
3	0.52	0.57	FM	0.32	0.56	IU
4	0.42	0.60	IU	0.19	0.47	IU
5	0.53	0.67	FM	0.40	0.50	IU
6	0.40	0.53	IU	0.31	0.68	IU
7	0.33	0.37	IU	0.28	0.43	IU
8	0.05	0.12	IU	0.08	0.43	IU
9	0.05	0.12	IU	0.06	0.15	IU
10	0.18	0.38	IU	0.21	0.42	IU
Ill-structured Problem						
1	0.33	0.48	IU	0.14	0.26	IU
2	0.22	0.45	IU	0.18	0.34	IU
3	0.18	0.28	IU	0.10	0.22	IU
4	0.05	0.16	IU	0.08	0.19	IU
5	0.32	0.89	IU	0.02	0.08	IU
Combined	0.33	0.44	IU	0.27	0.40	IU

As shown in Table 7, prior to instructions, participants under flipped classroom instruction were in the intuitive level of understanding in most of the items given in the mental model and ill-structured problem part of the Conceptual Understanding Test as revealed by the mean values ranging from 0.05 to 0.42 and with standard deviations ranging from 0.12 to 0.60. Majority of these items make use of students' knowledge on mole concept, mass relationship from balanced chemical equation, and concepts regarding limiting and excess reactant. This implies that students encountered difficulty in visualizing and understanding concepts of these particular topics.These were the topics that also required students' mathematical ability. Under traditional lecture, It can the level of understanding of the participants in traditional lecture was under intuitive understanding category in almost all the items, as reflected by the mean values ranging from 0.02 to 0.40 and with standard deviations ranging from 0.08 to 0.52. The combined mean of 0.33 (SD = 0.44) for the flipped classroom and 0.27 (SD = 0.40) for the traditional lecture revealed that before the instruction, students were in the intuitive understanding level in stoichiometry. Results showed that before the instruction, participants had no enough prior knowledge on stoichiometry.

Table 8. Level of Conceptual Understanding of the Students after the Instruction

Item	Flipped Classroom			Traditional Lecture		
	Mean	SD	Level	Mean	SD	Level
Mental Model						
1	3.02	0.74	CI	3.18	0.67	CI
2	2.63	1.01	CI	2.86	0.90	CI
3	2.82	0.85	CI	2.88	1.01	CI
4	3.10	1.24	CI	3.07	0.97	CI
5	2.77	1.07	CI	2.67	1.09	CI
6	2.92	1.27	CI	3.11	1.06	CI
7	3.50	0.67	BU	3.16	0.99	CI
8	3.08	1.33	CI	3.58	0.96	BU
9	2.72	1.17	CI	2.59	0.97	CI
10	2.32	1.09	PU	2.23	1.21	PU
Ill-structured Problem						
1	3.58	0.86	BU	3.31	1.27	CI
2	3.00	1.34	CI	3.68	0.91	BU
3	3.13	1.34	CI	3.69	0.81	BU
4	2.00	1.64	PU	2.92	1.22	CI
5	3.98	0.07	BU	3.76	0.89	BU
Combined	2.97	1.05	CI	3.11	1.00	CI

Table 8 shows that the students were in the best understanding level after the flipped classroom instruction in the 3 items of the test (item # 7 in part I, and 1 and 5 in part II) with mean values of 3.5 (SD = 0.67) , 3.58 (SD = 0.86), and 3.98 (SD = 0.07) respectively. The first 2 items have something to do with findings the number of moles/mass of a substance from the given reaction. Results imply that the students were able to understand and applied correctly concepts regarding the mole and mass relationship from balanced chemical equation after exposing them to a flipped classroom instruction. Item 5 of the test was unsolvable worded problem because of incorrect details which were intentionally constructed by the researcher. This item got the highest mean value among all the items indicating that the students easily identified that the problem given was ill-structured. This only means that students' metacognitive skills were developed after the flipped classroom instruction. This is because according toBransford [15]), an important characteristic involved in ill-structured problem solving is "metacognition" --the ability to monitor one's current level of understanding and decide when it is not adequate.

Eight (8) out of the 10 items in the mental model part, and 3 out of 5 items in the ill-structured problem part were categorized under the correct incomplete category, as reflected by the mean values ranging from 2.63 to 3.13 and with standard deviations ranging from 1.01 – 1.34. The aforementioned items involved analysis of chemical reaction using mental model, deriving balanced chemical reaction, identification of limiting and excess reactants and worded problems with minimal given, and with several solution to overcome before getting the final answer. From the results, students were able to understand these concepts after using mental models and ill-structured problems and exposing them to a flipped classroom environment. It is a clear indication that this new learning style does not only make class time more productive for both teachers and students, but also increases student engagement, and increases student conceptual change. Only in item number 10 in Part 1 of the test, with mean of 2.32 (SD = 1.09); and item 4 in part 2, with mean of 2.00 (SD = 1.64) where the students attained the partial understanding level. Item 10 required the students to draw their mental model of certain chemical reaction, given in the form of statements. Students encountered difficulty in representing chemical reaction using chemical equation. Reflected from the follow-up interview,students know how to make use of model to represent chemical reaction, but the problem was on translating chemical reaction into equation form. The same as item 10, item 4 of the ill-structured problem part required the students to derive the correct balanced equation before solving the given problem. This only implies that students still need to practice writing and balancing equation. Results revealed that success in solving general stoichiometry problems was significantly correlated with writing and balancing chemical equations. Combined mean of 2.97 (SD = 1.05) reveals that students attained correct incomplete level of understanding after their exposure to a flipped classroom instruction. Results suggest that absence of face –to- face lecture inside the classroom is not a hindrance for the students to understand concept in stoichiometry.

After the traditional teaching, majority of the items attained the correct incomplete level. The means obtained range from 2.59 to 3.31 and standard deviations range from 0.97 to 1.27. Four items attain the best understanding level, with means of 3.58 (SD = 0.96), 3.68 (SD = 0.91), 3.69 (SD = 0.81), and 3.76 (SD = 0.89); and one item with a mean of 2.23 (SD = 1.21) attains the partial understanding level. From the results, students fully understand items that asked them to draw the model of the product, to solve for the number of moles, to look for limiting reactants, and to identify unsolvable problems, but they find it difficult to make a model representing the reactants and products from the given reaction where chemical equation is not given.

The obtained combined mean is 3.11 with standard deviation of 1.00 which shows that the students attained correct incomplete level of understanding after the traditional instruction. As Reflected from the results, after the traditional lecture method almost all the items were answered by the students, only lacking details on their explanation.

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

As shown in Table 9, there are 4 items in the pretest that are in the functional misconception level changed into correct incomplete level after the flipped classroom instruction (Item # 1, 2, 3, and 5). Change for the better takes place on these items, which are in

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the semantic type. This only means that from the robust misconception, wherein the students were not able to answer the question and with completely wrong reason for their answer, it was changed to a sound conception but lacked only some details in their reason after the flipped classroom instruction.

Table 9 also reveals that six items under intuitive understanding level in the pretest (item # 4, 6, 8, 9, 2, and 3) were changed to correct incomplete level in the posttest after the flipped classroom instruction. From the no answer and guessing mode of the students it was changed to an accurate answer and sensible reasoning that only lacks small details. It is clearly manifested that change for the better takes place among these items that were categorized into theoretical conceptual change. Result implies that the students' explanation or solution have become coherent with the scientific principles involved after flipped classroom instruction. There are 3 items (item # 7, 1, and 5) in the intuitive understanding level during the pretest that are changed into best understanding level after the posttest, and are categorized to change for the better specifically under the theoretical category. Students were able to answer the items correctly with a complete and detailed explanation or solution. There are 2 items (item # 10 and 4) that are changed from intuitive understanding level in the pretest to partial understanding level in the posttest and are categorized to change for the better specifically under the semantic category. Combined results reveal that flipped classroom instruction catalyzed better understanding of stoichiometry. It can bring about theoretical conceptual change among students.

As shown in Table 10, after the traditional instruction majority of the items (item # 2, 3, 4, 5, 6, 7, and 9 in part I; and1and 4 in part II) in the pretest that are in the intuitive level of understanding are changed into correct incomplete understanding after the posttest. A change for the better, in theoretical type, was attained after the exposure of the students to traditional lecture method. This means that after the face-to-face instruction between the teacher and the students, the wrong answer of the students with no accompanying reason was changed to correct answer and reason but lacked only in details. It can also be seen that four items (item # 8 in part I, and 2, 3, and 5 in part II) under intuitive level of understanding are changed into best understanding, a theoretical type of change after the traditional lecture. There are also an items (item # 10 and # 4) from the intuitive level of understanding during the pretest that are changed to partial understanding and correct incomplete level, a semantic type of conceptual change after the posttest. Combined results reveal that after exposing the control group in a traditional lecture method a change for the better type of conceptual change is manifested among students and theoretical conceptual change exist among them.

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

Table 11 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 12 shows that there is no significant difference on the students' conceptual change on stoichiometry between the flipped classroom instruction (experimental group)) and traditional lecture method (control group), 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 lecture method in teaching stoichiometry.

1. Students' View on Their Journey in Measuring Conceptual Change in a Flipped Classroom Environment

As revealed in Table 13, the ten statements describing the flipped classroom instruction have a composite mean value of 3.5, which means that the respondents strongly agreed to most of the statements. The table reveals that majority of the students had a positive experience on their journey in a flipped classroom environment. As justified by their strong agreement to the eight descriptions regarding flipped classroom instruction. Students found flipped classroom helped them develop a positive attitude towards Chemistry and is appropriate for learning

College Chemistry which are in the first and second rank in the order distribution.

Table 9.Type of Conceptual Change as Determined from Pretest to Posttest of Students Exposed to Flipped Classroom Instruction

Item	Level		Type of Conceptual Change	Sub-type of Conceptual Change
Mental Model	**Pretest**	**Posttest**		
1	FM	CI	Change for the better	Semantic
2	FM	CI	Change for the better	Semantic
3	FM	CI	Change for the better	Semantic
4	IU	CI	Change for the better	Theoretical
5	FM	CI	Change for the better	Semantic
6	IU	CI	Change for the better	Theoretical
7	IU	BU	Change for the better	Theoretical
8	IU	CI	Change for the better	Theoretical
9	IU	CI	Change for the better	Theoretical
10	IU	PU	Change for the better	Semantic
Ill-structured Problem				
1	IU	BU	Change for the better	Theoretical
2	IU	CI	Change for the better	Theoretical
3	IU	CI	Change for the better	Theoretical
4	IU	PU	Change for the better	Semantic
5	IU	BU	Change for the better	Theoretical
Combined	IU	CI	Change for the better	Theoretical

Table 10.Type of Conceptual Change as Determined from Pretest to Posttest of Students Exposed to Traditional Instruction

Item	Level		Type of Conceptual Change	Sub-type of Conceptual Change
Mental Model	Pretest	Posttest		
1	FM	CI	Change for the better	Semantic
2	IU	CI	Change for the better	Theoretical
3	IU	CI	Change for the better	Theoretical
4	IU	CI	Change for the better	Theoretical
5	IU	CI	Change for the better	Theoretical
6	IU	CI	Change for the better	Theoretical
7	IU	CI	Change for the better	Theoretical
8	IU	BU	Change for the better	Theoretical
9	IU	CI	Change for the better	Theoretical
10	IU	PU	Change for the better	Semantic
Ill-structured Problem				
1	IU	CI	Change for the better	Theoretical
2	IU	BU	Change for the better	Theoretical
3	IU	BU	Change for the better	Theoretical
4	IU	CI	Change for the better	Theoretical
5	IU	BU	Change for the better	Theoretical
Combined	IU	CI	Change for the better	Theoretical

Table 11.Average Normalized Gains for the Two Groups of Respondents

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

Table 12.Comparison of the Hake Factor Results of the Controland Experimental Group

Groupings	g	SD	t-value	p-value	Interpretation
Control	0.76	0.14	1.031	P = 0.308 > 0.05	NS

Experimental	0.72	0.16

Table 13.Students' View on Their Journey in Measuring Conceptual Change in a Flipped Classroom Environment

Description Flip classroom ...	Mean	Verbal Interpretation	Rank
1. was enjoyable and interesting method of teaching.	3.50	Strongly Agree	5
2. helped me understand concepts in stoichiometry easily.	3.45	Agree	8.5
3. made me use my study time more effectively.	3.35	Agree	10
4. increased my appreciation in learning stoichiometry.	3.50	Strongly Agree	5
5. helped me gain a clearer understanding of the lesson.	3.45	Agree	8.5
6. encouraged me to study independently.	3.50	Strongly Agree	5
7. made me more mentally active in the learning process.	3.50	Strongly Agree	5
8. helped me develop a positive attitude towards chemistry.	3.65	Strongly Agree	1
9. helped me develop my study habits at home.	3.50	Strongly Agree	5
10. was appropriate for learning college chemistry.	3.60	Strongly Agree	2
Composite Mean	**3.50**	**Strongly Agree**	

CONCLUSIONS

The third year science major Education students have intuitive level of conceptual understanding of stoichiometry using mental models and ill-structured problems before the exposure to flipped classroom and traditional lecture method, 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. There is no significant difference on the students' conceptual change on stoichiometry exposed to flipped and traditional lecture method.The integration of flipped classroom environment which are anchored on constructivists approach for teaching is an effective classroom strategy in fostering conceptual change. Mental models and ill-structured problems can be used in measuring conceptual change among students.The use of flipped classroom instruction elicits a positive attitudetowards Chemistry and useful in understanding the different topics in stoichiometry, thus teachers must exposed their students in this kind of learning structure.

RECOMMENDATIONS

It is recommended to continuously diagnose students' misconceptions and address the same in other science courses using interactive engagement techniques which are anchored on constructivist approach for teaching. The use of mental model and ill-structured problem in flipped classroom instruction on developing conceptual change should be tried out in different disciplines and venues. Further study can be initiated to address the areas where alternative conceptions exist and to identify teaching and assessment strategies to correct misconceptions.

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