Enhancing Achievement Motivation, Interaction, and Academic Achievement of High School students in a Flipped Classroom

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Abstract: Helping students to stay motivated by creating an environment that makes them interact is essential to attaining academic achievement. This action research utilizing mixed methods approach explores the flipped classroom's impact on the students' achievement motivation. Also, a significant focus has been on how students interacted with their classmates, the teacher, and the content. The online course management MyOpenMath was utilized in the first cycle of the study. Descriptive statistics was utilized in the study to analyze the results of the adapted Four Dimensions of Achievement Motivation, Flanders' Interaction Analysis Matrix, and students' Chapter Test grades for academic achievement. Observations by the department chair were utilized to establish themes. It is through concurrent triangulation that the researcher understood convergence, differences, and combination of data. The data show that there is a significant improvement in students' achievement motivation except in the strive dimension. Class observation analysis revealed less teacher talk, more pupil talk, and slight increase in silence or confusion. None of the students failed in their Chapter Test. The Analyze-State-Select-Utilize-Require-Evaluate (ASSURE) model was deemed to best fit the guiding principles in Algebra 2/Trigonometry course delivery based on the study's results.

Keywords: Flipped Classroom, MyOpenMath, Achievement Motivation, Interaction, Academic achievement

INTRODUCTION

The goal of more meaningful interactions among students and with the teacher is at the heart of every teaching and learning session, which aims at students doing and learning mathematics. Teachers enjoy and find it fulfilling to notice their students experiencing an "AHA" moment by helping them discover things and just be able to facilitate their learning rather than passively delivering the lesson. Learning entails teachers closely monitoring students' work, their thinking processes, and providing feedback in formative assessments and classroom activities. There have been a significant number of studies that link flipped classrooms and students' academic achievement. A flipped classroom, also known as the inverted classroom, changes the role of responsibilities in class. For example, lectures and other materials are posted on the learning platform so students can study the lesson/s before the synchronous session. Then, clarifications and questions, generating more examples, and deepening the concepts occur during classes (Song et al., 2017; Safapour et al., 2019). While the first researcher wants students to improve their scores in assessments, he also wants to understand more about how students interact in a flipped classroom and to what extent students are motivated in a mathematics class in terms of the *Four Dimensions of Achievement Motivation* (FDAM) namely strive, participation, willingness to work, and maintaining the working.

LITERATURE REVIEW

Our world is undergoing "digitalization." Teachers have used technology to deliver lessons, conduct assessments, access resource materials, and many more. Thus, education and people in the field must not stop to adapt and address the conditions, trends, needs, problems, and demands of stakeholders in this age.

The study of Parra-González et al. (2020) is one of the promising articles the researcher read, which sparked the initiative to incorporate a flipped classroom and maximize assessment tools like MyOpenMath. A flipped classroom, also known as the inverted classroom, changes the role of responsibilities in class. For example, lectures and other materials are posted on the learning platform so students can study the lesson/s before the synchronous session. Then, during classes, clarifications and questions, generating more examples, and deepening the concepts occur (Song et al., 2017; Safapour, Kermanshachi, and Taneja, 2019).

Flipped classroom falls under the umbrella of blended learning. The term "reverse" is closely associated with flipped classroom as this instructional strategy which switches the delivery of instruction (teacher lecture) and doing tasks and homework. In a flipped classroom, teacher-led instruction is done outside of class by making students watch a pre-recorded or pre-selected videos and other forms of learning materials and "devoting class hours to accomplish tasks under the teacher's supervision and facilitation (Baybayon & Lapinid, 2024).

According to Afrifa-Yamoah, E. (2016), the concept of achievement motivation has always been viewed as a "complex human incentive" that paves the way for results being brought about. It stimulates a systematic pattern of behavior towards the desired ends, continuously urging them until effects manifest.

The very nature of achievement motivation is social-psychological. It often occurs within groups, where interpersonal interactions can undermine or facilitate engagement in the activities needed to be accomplished (Maehr, 2008).

The need for achievement shows itself as a desire to complete a task or behavior according to perfection or even better than these criteria. For example, reaching or obtaining a problematic goal, solving a complex problem, improving skills, and completing homework show the need for achievement. Individuals with high achievement are expected to take reasonable risks and prefer activities that can be achieved quickly, reach inner satisfaction stemming from their successes, and do not care for anything except their tasks. On the other hand, a low need for achievement is associated with a sense of low competence, low expectations, and an orientation toward failure (Erdogan et al., 2011).

Academic achievement is an essential construct because achievement motivation can contribute to increased student participation, which in turn may help them improve their academic performance and succeed in the course. Achievement motivation is vital in the fields of psychology and education because it is seen as a robust predictor of students' educational attainment (Ligon, 2006, as cited by Clark, 2010).

According to Martin & Rimm-Kaufman (2015), we build relationships with ourselves and other people around us. Take, for instance, inside the classroom or in an online class. Whenever students engage with their classmates and teachers, interaction takes place. Interaction is considered a "multi-faceted construct" in that it involves specific components like psychological and behavioral. Students often communicate with their teachers to answer, ask questions, clarify matters, or suggest things. We call this student-teacher interaction, which is considered a critical thing in learning. Student-teacher interaction may come in different forms: emotional (to be sensitive, aware, and responsive to student's needs and interests), organizational (by creating an environment that is conducive to learning, clear goals, and productive learning), or instructional (delivery of content, modeling concepts, provision of feedbacks, and creation of opportunities to learn) in nature.

The interaction may involve the sender asking questions to the receiver. There are issues involving interaction in class, such as not all students communicating or responding in the classroom. Hence, this needs to be addressed by using ways of communicating and questioning that encourage students to participate during class interaction. Communication is essential because teacher-student or student-student interactions pave the way to building meaningful transactions to learn (Chin, 2006).

The work of Hazel & Mortensen (2017) added to the body of knowledge about the definition of classroom interaction. Its primary focus revolves around three pieces of evidence of participation: allocating turn, choice of language, and personal boundaries. Turn allocation is how either the teacher selects students to participate in a class or students are the ones who volunteer and "indicate their willingness to participate." Choice of language is the selection of how students express their thoughts or ideas in a classroom. Personal boundaries refer to the limitation or to what extent students want to distance themselves physically or emotionally from other people around them. On the other hand, the order of interaction may also have adverse outcomes. When interacting with peers, conversation/s may lead to "exclusion or categorization," which hinders a harmonious relationship.

According to Weidinger et al. (2020), students' academic achievement refers to the extent which indicates their outcomes in terms of performance accomplished with specified goals in an institution like in schools. Academic achievement includes acquiring knowledge and understanding in "numeracy, literacy, science, and history." Studies have shown many factors that affect the academic achievement of students. Two factors that were said to affect it are interaction and achievement motivation. In the study of Nugent (2009), the researcher concluded that there was a "statistically significant relationship among interaction, student motivation, and academic achievement" of students. Furthermore, the study necessitated data collection, identifying "the variables (e.g., motivation, achievement, and interaction) and evaluating these" utilizing quantitative methods and techniques. In addition to the results of his study, he added that creating class environments that nurture "positive cultures" with healthy or vigorous interactions can motivate students to channel their desires and energies into reaching their targets – paving the way to academic achievement in school.

This action research is anchored on the *Interaction Equivalency Theorem* developed by Terry Anderson (Anderson, 2003). This theorem supports the idea that deep and meaningful learning can still occur as long as one of the forms of interaction (student-student, student-teacher, student-content) is at its high level.

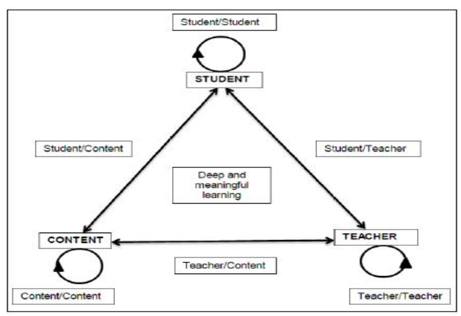


Figure 1. Interaction Equivalency Theorem Model (Source: Lane, 2014)

Figure 1 shows the Interaction Equivalency Theorem Model. This theorem was anchored in three underlying theories: expectancy-value theory (EVT), self-determination theory, and self-regulation theory. EVT explains that students' motivation depends on their belief in succeeding in a subject and the value of learning it. Expectancy-value theory can best be represented in a classroom where a student confidently does tasks or submits outputs on time or ahead of time (Leaper, 2011). Second, the self-determination theory assumes human beings are naturally curious about their environment and inherently desire and have interest in learning (Niemiec & Ryan, 2009). This theory explains that students have personal reasons for accomplishing a task (intrinsic motivation) or want something like a reward (extrinsic motivation). Lastly, self-regulation theory expounds that students can be active agents of their learning by being responsible in setting their goals, selecting how to study, structuring a safe learning environment, monitoring their performance, and planning how they will exert effort on these responsibilities (Junaštíková, 2023).

RESEARCH QUESTIONS

This study's purpose is two-fold. It sought to analyze achievement motivation with its four dimensions and students' academic achievement, and the interaction of students with their classmates, teacher, and content in a flipped classroom environment. Specifically, the study was pursued to answer the questions:

1. What is the students' achievement motivation in the mathematics class before and after the flipped classroom?

2. What are the students' academic achievement in mathematics after the flipped classroom?

3. How do students interact in the flipped classroom environment in terms of:

    a. student-student interaction,

    b. student-teacher interaction, and

    c. student-content interaction?

METHOD

This study is the first cycle of an action research with the primary goal to improve one's delivery of instruction to aid students acquire deep understanding of mathematics concepts. The mixed methods approach was used for a more comprehensive understanding of the data gathered. For the quantitative method, descriptive statistics was utilized in the study to analyze the results of the adapted FDAM, *Flanders' Interaction Analysis Matrix*, and students' *chapter test* grades for academic achievement. For the qualitative method, the observations by the department chair were utilized to establish themes. Ultimately, it is through concurrent triangulation that the researcher understood possible "convergence (confirmation), differences (disconfirmation), and combination (cross-validation or corroboration) (Creswell, 2009)."

Before data gathering commenced, the researcher sought permission from the principal. This move informed the school administration of the teacher's intention to conduct the action research. After their approval, the researcher submitted a letter to the Public School District, which informed our Superintendent and sought permission to conduct the study in the school. The teacher received an approval letter allowing the study to be conducted with attached reminders on ethics and students' anonymity. They were given an orientation on MyOpenMath before the flipped classroom was incorporated. This orientation included the creation of their MyOpenMath account and enrolling in the researcher's course as well. After their orientation, the Informed Consent Form addressed to their parents was given to students. Parents were given essential details of the extent of their children's participation in the study. All students returned their parents/guardians forms signifying their support in the conduct of the study. Twenty-five (25) students (10 female and 15 male) enrolled in the Algebra 2/Trigonometry course during the entire semester in a public school in Ralston, Nebraska, participated in this action research. The class is diverse in terms of its ethnicity which is composed of 13 White, 5 Hispanic, 2 Black, 1 Asian, and 4 multiracial students.

A student enrolled in the school must be able to attain 30 credit hours in Mathematics. Some credit hours (10 credit hours) should be earned above Pre-Algebra level courses. Algebra 2/Trigonometry is a course offered to Grade 9 students who were assessed as having strong mathematics foundation in the middle school. Incoming Grades 10, 11, and 12 students who successfully passed their Algebra 2 course are also welcome to enroll in this course. This course is a prerequisite of either the Trigonometry or the Pre-calculus course and runs in a full quarter consisting of 9 weeks of instruction. Algebra 2/Trigonometry course is delivered every other day with 1 hour and 30 minutes is allocated for the topic/s to be delivered every session. The teacher follows a "5-10-30-45" pattern most of the time. This schedule pertains to how a class is facilitated every session: 5 minutes for review of previous topic/s, 10 minutes to facilitate daily quiz, 30 minutes for delivery of instruction, and 45 minutes for students to accomplish the worksheet/homework and for the teacher to guide them individually most especially those who are struggling or those who have questions. The teacher is strictly following the time allotment depending on the complexity of the lesson topic.

The utilized instruments consisted of the teacher's journal, students' journals, the achievement motivation questionnaire, *Flanders' interaction analysis matrix*, student-student interaction rubric, and the chapter test. The researcher utilized MyOpenMath to aid in the intervention of the flipped classroom. The teacher-researcher wrote his journal as he ventured with his students into a flipped classroom using Google Forms. The journal's results and what transpired during the class were intensively articulated. Students were tasked to write a journal from orientation until the end of the study. In addition, there was an allotted space for them to reflect.

The four dimensions of achievement motivation was intensively studied, formulated, and tested by Afrifa-Yamoah (2016) which consisted of 20 items. Those items were intended to measure the student's achievement motivation, including striving, participation, willingness to work, and maintaining the work on a 5-point Likert scale reflecting 1-never, 2-rarely, 3-sometimes, 4-often, and 5-always. A Cronbach alpha reliability coefficient of 0.79 was obtained indicating the instrument's reliability.

The Mathematics department chair was requested to observe the class utilizing Flanders' Interaction Analysis Matrix by coding, and the 10-category system aided the observer in categorizing all verbal behaviors during synchronous class. As such, the observer was oriented on how to use this instrument. This research instrument, which captured qualitative and quantitative dimensions of student-teacher interaction in the flipped classroom, was developed by Ned Flanders (Amatari, 2015). The matrix has rows and columns numbered from 1 to 10. The rows reflect action-observables and the columns responses by the teacher to students, or vice versa. For example, a teacher that asks a question (category 4) but no student responded (category 10), the observer indicates this as an occurrence and writes a stroke in the fourth row across the tenth column. Teacher-Talk, Pupil-Talk, and Silence or Confusion percentages were computed considering column totals based on the categories 1 to 7, 8 and 9, and 10, respectively.

Students answered the adapted FDAM before the intervention. After the collection of responses, the teacher started the incorporation of a flipped classroom. Students were given the guide questions they had to answer after watching the assigned videos. The class was observed during the intervention proper. The teacher and students then wrote a journal about their experiences in the flipped classroom. After all observations, the teacher used the adopted instrument *student-student interaction rubric* (Middle School and high school collaboration rubric, 2018) to rate the students based on their interactions with their classmates. In addition, students' assessment scores, like their grades in daily work, class activities, and tests, were utilized for in-depth understanding of their academic achievement. After the intervention, student participants answered the adapted FDAM again. The *student-student interaction rubric* made grading more objective because it became apparent to them how the teacher grades them based on each criterion. The rubric contains six criteria, and the highest possible score per criterion is three points. There is an explanation for each point in each measure. Lastly, students' scores in their *chapter test* reflected highly if the intervention helped them to learn the lesson. In the past years, chapter tests have always been graded using the equivalent percentage of student scores.

The students were allowed to use only the basic calculator but not the scientific calculator in the study because the topics covered in this action research are about exponents and radicals, where most items are solvable in just one click using a scientific calculator. Although a basic calculator has fewer functions, students have maximized using it in operations such as multiplication and division to save time and focus on analyzing problems.

The study included 25 respondents. A Shapiro-Wilk test was conducted, and the standard deviation was calculated to assess whether the data met the assumptions for performing a t-test. The Shapiro-Wilk test result was 0.922, which is greater than the significance level of 0.05 ($p = 0.918$), indicating that the data is normally distributed. Additionally, the variability of differences between each pre-test and posttest scores is not large and the standard deviation was 0.632, indicating low dispersion, meaning the students' responses did not vary significantly, and the effects of the intervention were relatively consistent among students. All these warranted the use of t-test which was deemed appropriate for this study.

RESULTS

Achievement Motivation

The *strive* dimension consisted of six expressions that aimed to understand how students perceive their effort to become successful in the course by pushing themselves to achieve good results. As reflected in Table 1, it is only in this dimension that the t-test result revealed no significant difference before and after the intervention because the p-value (0.210) is greater than the confidence level (α = 0.05). This result means that even when the mean slightly increased after the intervention, students still strived in a mathematics flipped classroom, almost similar to before incorporating the intervention. The *participation* dimension has five expressions that check whether students think they involve themselves in the learning process. The result of t-test revealed a significant difference between the mean of students' achievement motivation in the *participation* dimension before and after the intervention because the p-value (0.039) is less than the confidence level (α = 0.05). This result means students became more motivated to participate in a Mathematics flipped classroom.

Willingness to work is the third dimension and looks at students' persistence in doing tasks in mathematics and their will to be successful at school. Furthermore, this can be linked to how students perceived their study habits and their emotions on tasks that were done and those they failed to accomplish. The result of t-test revealed a significant difference between the mean of students' achievement motivation in the *willingness to work* dimension before and after the intervention because the p-value (0.023) is less than the confidence level (α = 0.05). This means that students became more willing to work in a mathematics flipped classroom. It can be seen on the next table that all the means of expressions in the *willingness to work* dimension significantly increased after the intervention.

Groups	Mean	SD	t	df	p-value
Strive					
Before intervention	3.873	0.23	-0.877058	24	0.210
After intervention	3.980	0.34			
Participation					
Before intervention	2.024	0.69	-2.3610602	24	0.039*
After intervention	2.768	3.84			
Willingness to Work					
Before intervention	3.040	1.11	-3.3070695	24	0.023*
After intervention	3.520	0.85			
Maintaining the working					
Before intervention	3.288	1.03	-2.9018255	24	0.022*
After intervention	3.784	0.69			
Overall					
Before intervention	3.098	1.13	-4.0623435	24	0.0003*
After intervention	3.536	1.06			

*Significant at α = 0.05

Table 1. T-test results of Students' Achievement Motivation

The last dimension *maintaining the working*, which looks closer to the consistency of students in studying mathematics. This dimension focuses on the character of students to strive for excellence. The result of t-test revealed a significant difference between the mean of students' achievement motivation in the *maintaining the working* dimension before and after the intervention because the p-value (0.022) is less than the confidence level ($\alpha = 0.05$). This result means students successfully maintained their work ethics in a mathematics-flipped classroom. It can be seen on the next table that all the means of expressions in maintaining the work dimension increased significantly after the intervention. There are 18 out of 20 expressions whose means increased after flipping the classroom. The two expressions whose mean decreased can only be found in the first dimension, the *participation* dimension. These statements were negatively stated and the response ratings were reversed for the computation of the means and standard deviations. The increase in mean ranges from 0.08 to 1.88. The expression "I like being successful at school" has the least increased mean equal to 0.08. Before incorporating the study, most students communicated that they want to be successful in whatever they did in school. Please see Table 2 for the pretest and posttest students' *achievement motivation* means and standard deviation on each expression.

The scale of the expression	BEFORE		AFTER	
	Mean	Std. Dev.	Mean	Std. Dev.
I try persistently to solve questions in mathematics lessons even when I fail	3.56	1.19	3.92	0.86
I try to do the best in whatever I do	3.68	1.27	4.04	1.06
Being successful at easy tasks that anyone can do does not give me pleasure	3.84	1.12	3.48	1.12
I enjoy answering difficult questions in mathematics lessons	4.08	1.28	4.28	1.14
To take low marks in mathematics lessons makes me sad	3.92	1.35	3.76	1.27
I would like to get the highest mark in mathematics lessons	4.16	1.35	4.40	0.96
I revise my notes before mathematics lessons	1.96	1.11	3.84	1.03
I study mathematics lessons even when it is not our testing period	1.84	0.92	2.00	1.08
I enjoy studying mathematics lessons	2.36	1.11	3.20	1.35
I get interested when I start studying mathematics lessons	1.04	1.27	1.20	0.91
I want difficult topics to be taught instead of easy topics in mathematics lessons	2.92	1.30	3.60	1.11
I like being successful at school	4.48	1.04	4.56	0.82
I get disturbed when I cannot finish my mathematics homework	2.64	1.12	3.12	1.30
I try to learn more than taught	1.84	1.28	2.60	0.91
I start studying after mathematics lessons	3.20	1.07	3.80	1.35
I feel better when I am successful at school	4.24	1.04	4.44	1.04
I review mathematics lessons even if I don't have exams	2.12	1.03	3.16	1.07
I study more than what is taught in class	2.36	1.11	3.12	0.93
I try to understand mathematics lessons	4.32	0.85	4.56	0.71
I try my best to gain my mathematics teacher's approval	3.40	0.85	3.64	1.19
Average Total	**3.098**	**1.13**	**3.536**	**1.06**

Table 2. Students' Achievement Motivation in a Flipped Classroom

With an increased mean of 1.88, the expression "I revise my notes before mathematics lessons" got the highest increase in mean. Students in their journals admitted that they have maximized their study time and asynchronous classes. They have utilized their notes during these times.

Meanwhile, the third expression, “Being successful at easy tasks that anyone can do does not give me pleasure,” and the fifth expression, “To take low marks in mathematics lessons makes me sad,” decreased their mean by 0.36 and 0.16, respectively. Having only two expressions to have slipped means before and after flipping the classroom was the main reason for a significant difference after the intervention when run through a t-test. Overall, the average mean increased from 3.098 to 3.536, decreasing the standard deviation from 1.13 to 1.06. As presented in Table 2, the result of t-test revealed that there is a significant difference between the mean of *students' achievement motivation* before and after flipping the classroom because the p-value (0.0003) is less than the confidence level (α = 0.05) implying *students' achievement motivation* improved in the incorporated flipped classroom.

Academic Achievement

When flipped classroom was incorporated, the teacher gathered the students' academic performance through MyOpenMath and the result of the *chapter test*. Students' academic achievement in mathematics indicates the extent to which they have understood the lesson as indicated in the learning targets and accomplished tasks given by the teacher.

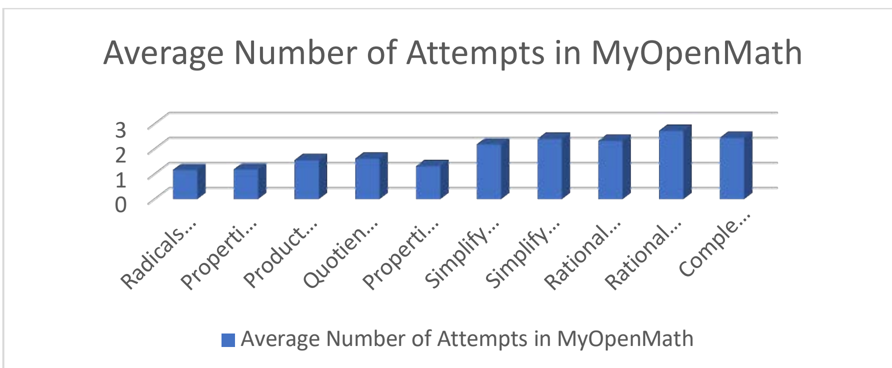


Figure 2. Average number of attempts in MyOpenMath

Figure 2 presents the Average number of attempts in MyOpenMath of student participants. There has been a continuous increase from the first topic through the fourth topic on the number of attempts made by students in MyOpenMath. This result can be highly attributed to students' knowledge of using proper symbols in MyOpenMath. Most students already knew the answer in items but struggled to encode their responses online. The number of attempts went down on the fifth topic because students had already mastered encoding their answers. Then, from the sixth to the last topic, the average attempts stayed consistently above two (2) attempts. This was not because of students' erroneous symbols and these incidents can be attributed to the difficulty of the topics.

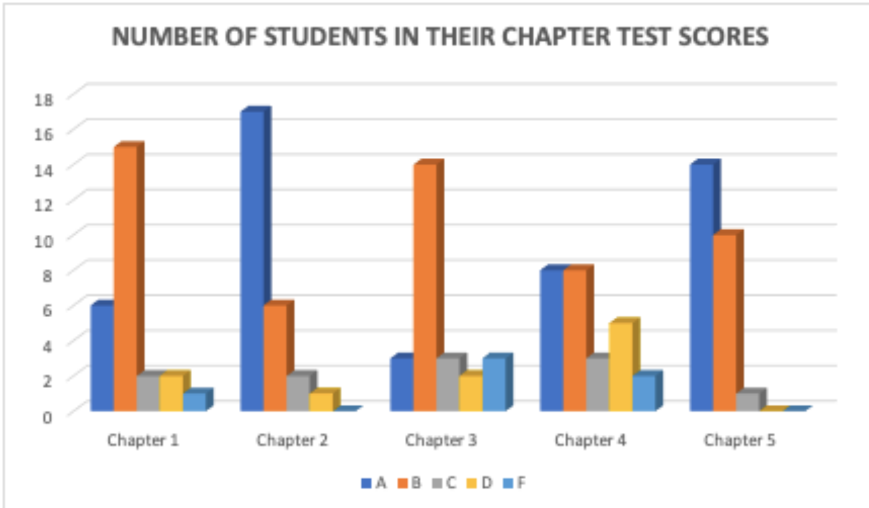


Figure 3. Number of students in their Chapter Test Scores

The number of students in each *chapter test* scores is shown in Figure 3. Students were given two attempts. In Chapter 1, there were six (23%) students who got an A grade. These students attained this grade for the Chapter 1 Test on their first attempt to take the test because the highest possible grade that a student who retakes a Chapter Test is 90 (B+). More than half of the class, or 15 (58%) students, got a grade of B. For C and D grades, 2 (8%) students got either the first or the latter mentioned above. One (4%) student obtained an F, equivalent to a failing grade. This student failed in both attempts in the Chapter 1 Test.

In Chapter 2, there were 17 (65%) students who obtained an A in the test. The number of students getting an A is equivalent to more than half of those taking the Algebra 2/Trigonometry students (where the population is 26). Then there were six (23%) students who got a B, two (8%) students got a C, only one (4%) got a D, and no student got an F in the Chapter 2 Test.

In Chapter 3, three (12%) students achieved an A grade. More than half of the students enrolled in the course, specifically 14 (56%), got a grade of B. There were also three (12%) students who garnered a grade of C, and there were two (8%) students who got a D. Like the number of students who got an A and C, there were also three (12%) students who failed in Chapter 3 Test and got an F amidst taking the test twice. This is by far the greatest number of students who got the lowest chapter test scores and very few students who got the highest scores.

Surprisingly, in Chapter 4, eight (31%) students earned an A, and another set of eight (31%) students got a B on the test even when the test consisted of the most challenging topics in the first semester (operations with rational expressions, rational equations and its roots, extraneous roots, and synthetic division). On the other hand, three (11%) students got a C, and five (19%) students in the class got a D. As expected, there will be students who fail the test even after two tries. There were two (8%) students failed and got an F in the test.

In Chapter 5, the number of students who got an A is 14 or more than half of the class. There were 10 students who got a B, and 1 student got a C. There were no students who got a D or who failed (F grade) in this chapter. This is the reason why there was no student who took a retake of the Chapter 5 Test. Nonetheless, most of the students performed very well with grades A or B across the different chapters with very few students failing.

There were 23 learners who got 80% or higher in the Properties of Exponents Worksheet. There was an absentee and another one was not able to answer it. Meanwhile, 20 learners got 80% or higher in the Properties of Radicals Worksheet and only 16 students in Simplifying Radicals Worksheet. Based on the data gathered, 21 learners earned a score equivalent to 80% or higher in their first daily quiz while there were 20 and 16 students who attained this in their second and third daily quizzes, respectively. There were two (2) learners who needed remediation on the first topic – the one who was absent and the other who did not answer in MyOpenMath. On the other hand, five (5) students needed more assistance from the teacher on the second topic. Likewise, nine (9) students were required to answer additional exercises.

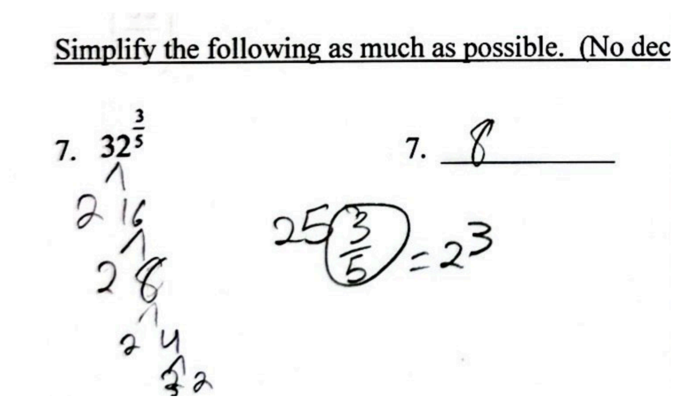
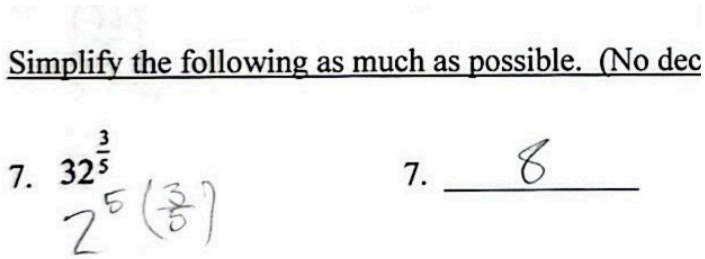


Figure 4. Solution and answer of Student A in item number 7 of Chapter 5 Test

Figure 4 shows Student A’s solution to the 7th item on Chapter 5 Test and the final answer. The student used the pair method and identified the prime factors of 32 by prime factorization, specifically by using a factor tree. Two more students have similar solution with Student A. Then, the students figured out that there were five 2’s that maketh 32 so the student wrote it in exponential form as 2^5 (looking like a 25 in the student’s solution). In addition, the student affixed the exponent $\frac{3}{5}$ to it. Based on how the student’s solution, the student cancelled the 5’s (after multiplying the exponents 5 and $\frac{3}{5}$) and got 2^3. The student then evaluated and wrote the correct final answer 8.


Simplify the following as much as possible. (No dec

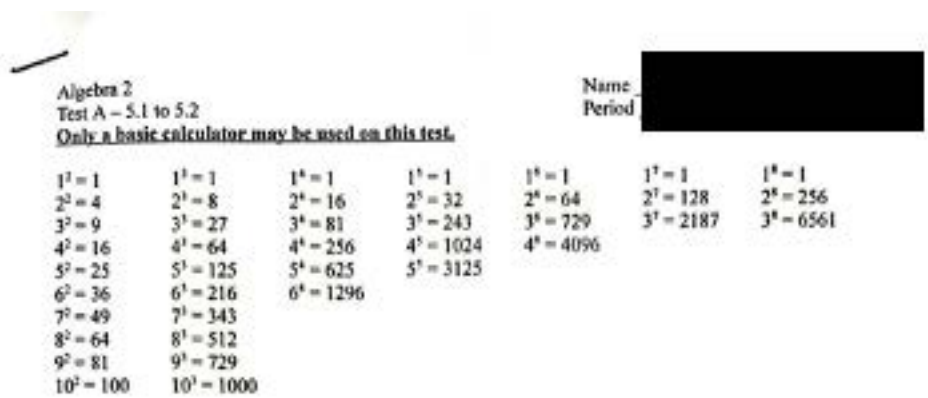
7. $32^{\frac{3}{5}}$

$2^{5}\left(\frac{3}{5}\right)$

7. 8

Figure 5. Solution and answer of Student B in item number 7 of Chapter 5 Test

A different solution was provided by Student B based on Figure 5. Unlike Student A, Student B maximized the utilization of the provided *Exponents Chart* (see Figure 6). Student B wrote 32 in exponential form 2^5 with the intention of multiplying it with the exponent $\frac{3}{5}$. Even though Student B has shorter solution in comparison with Student A, both students received full credits for the item based on the *Test Scoring Guide* (see Figure 7).


Algebra 2
Test A – 5.1 to 5.2
Only a basic calculator may be used on this test.

Name [redacted]
Period

$1^2=1$	$1^3=1$	$1^4=1$	$1^5=1$	$1^6=1$	$1^7=1$	$1^8=1$
$2^2=4$	$2^3=8$	$2^4=16$	$2^5=32$	$2^6=64$	$2^7=128$	$2^8=256$
$3^2=9$	$3^3=27$	$3^4=81$	$3^5=243$	$3^6=729$	$3^7=2187$	$3^8=6561$
$4^2=16$	$4^3=64$	$4^4=256$	$4^5=1024$	$4^6=4096$		
$5^2=25$	$5^3=125$	$5^4=625$	$5^5=3125$			
$6^2=36$	$6^3=216$	$6^4=1296$				
$7^2=49$	$7^3=343$					
$8^2=64$	$8^3=512$					
$9^2=81$	$9^3=729$					
$10^2=100$	$10^3=1000$					

Figure 6. *Exponents Chart* provided to students in front page of Chapter 5 test

For Chapter 5 Test, only a basic calculator was used by the students so the teacher provided the students with the *Exponents Chart* from exponent 2 to 8 (incomplete).

Algebra 2 Unit 5A Test Scoring Guide **53 POINTS - convert score to %**

#1-4: 1 points	Right or wrong
#5: 2 points	One point for dividing by coefficient, one point for taking the cube root. Or -1 for each error
#6: 3 points	One point for taking the root, one point for moving the 8 over correctly, one point for having two answers. Or -1 for each error
#7-10: 1 points	Right or Wrong
#11: 2 points	11: one point for negative, one point for root and cube
#12: 2 points	12: one point for numbers one point for variables
#13: 2 points	13:1 point for flipping 1 point for correct numbers
#14: 1 points	Right or wrong
#15: 2 points	One point base, one points exponent (-½ if not reduced)
#16: 1 points	Right or Wrong
#17: 2 points	One point for base one point for exponent
#18: 3 points	One point for combining radicals, one point for pulling number out, one point for correct radical left over
#19: 2 points	One point for dividing, one point for taking root
#20: 3 points	One point for multiplying top and bottom by something that rationalizing denominator, one point for simplifying top, one point for simplifying bottom
#21: 3 points	One point for multiplying by conjugate, one point for correct numerator, one point for correct denominator
#22: 4 points	One point for numbers, one point for each variable

Figure 7. Chapter 5 Test *Scoring Guide*

All Chapter Tests given to students have their corresponding *Scoring Guide* just like what Figure 7 illustrates for Chapter 5. This is needed to grade students' tests objectively in line with the state's learning targets. It means that teachers are really evaluating whether students have mastered the state standards or not. The information in the first column were the item number and the corresponding point/s that the teacher-researcher can give to students.

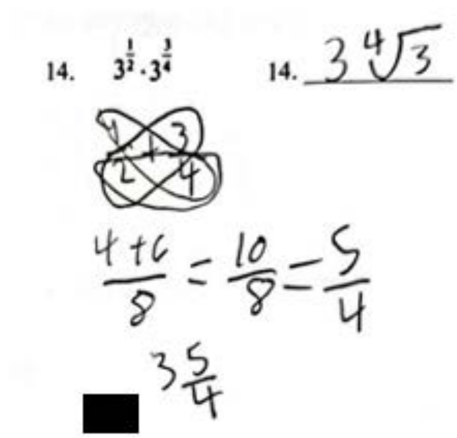


Figure 8. Solution and answer of Student C in item number 14 of Chapter 5 Test

Figure 8 shows Student C's solution and answer in item number 14. The student used the butterfly method in adding the fractions. The student multiplied the numerators and denominators of the fractions diagonally and added them together and arrived with 10. Student C, then multiplied the denominators of the fractions and calculated 8. The student simplified the new fraction that was attained into $\frac{5}{4}$. Ultimately, from $3^{\frac{5}{4}}$, Student C wrote the final answer in simplest radical form $3\sqrt[4]{3}$. Student C received full credits in this item.

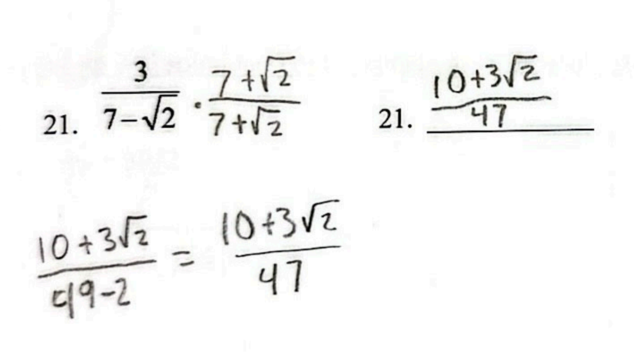


Figure 9. Solution and answer of Student D in item number 21 of Chapter 5 Test

Figure 9 shows the solution and answer of Student D in item number 21. Student D set up the conjugate to be multiplied with the numerator and denominator. However, the student added 3 and 7 instead of multiplying them which is why the student wrote 10, which is wrong. Nevertheless, the denominator was solved correctly which is why Student D still received 1 point out of the 3 points (see Figure 7 for the details on how the teacher graded each item in this test).

Interaction

Student-student Interaction

Students interacted with their peers during the Kahoot! activity. There were pairs who brainstormed in each item. Some followed a strategy where one student key in their answers and the other solved for it while there were pairs where both students solve for the items and whoever solved first also key in the answer. The students who did not solve still contributed a thing or two on their pair who solves because they were looking on their solution and final answer. This strategy was a form of double-checking and the teacher noticed in the recording that these students who did not solve communicated to their pair when they saw something wrong on what their teammate did. In addition, the teacher did not see any negative effects on students who did not solve because all students were informed that they would be assessed individually through worksheets so they must learn the topics for them to be able to accomplish the individual worksheets which prompted them to closely observe their team mates solving.

Table 3 shows the average score given by the teacher to students for their interaction with their classmates using the adapted rubric in the study. The rubric is anchored on six (6) criteria and students can get a score of 1, 2, or 3, with 3 being the highest score for each criterion. The highest possible total score is 18. Getting the sum of the mean scores per criterion, it summed up to 15.04. This score is above the 80% of the highest possible score.

		Average Score
Focus on the Task and Participation		2.52
Dependability and Shared Responsibility		2.56
Listening, Questioning, and Discussing		2.44
Research and Information-Sharing		2.32
Problem-Solving		2.36
Group/Partner Teamwork		2.84
	Total	15.04

Table 3. Average score for Student-student Interaction

In the rubric, “dependability and shared responsibility” garnered a mean score of 2.56. The score for this second criterion is very close to the mean score of the first criterion. Most students were exemplary in accomplishing tasks on time and were very responsible for tasks be it as an individual, with a pair, or in groups.

Figure 4. Eagerness of group representatives in answering during a whisper relay game

Figure 5. A pair of students in front (left) were observed to be collaborating during a game

The third one, "listening, questioning, and discussing" garnered a mean score of 2.44. There were a lot of students who respectfully listened, interacted, discussed, and posed questions to the teacher and their classmates during discussions. However, this criterion could have been better if only other students have actively engaged themselves on the listening, questioning, and discussing moments. Nevertheless, students were observed to be asking relevant questions and were attentive in listening to the teacher during classroom discussions. There were many pictures showing and supporting this claim.

Figure 6. A student raises her hand to ask a question about the activity

Three observations on Student Interaction were tabulated by the Mathematics Chair in Table 4 after watching the three (3) video recordings. Then, the researcher was able to compute the important ratios using Table 8 in analyzing patterns of interactions. These three ratios are Teacher Talk (TT), Pupil Talk (PT), and Silence or confusion (SC). Please see Table 5. The highest tabulated score was at 87 which is the pupil-talk-response. When the teacher asked some questions, most students answer, but there are some who raised their hands for clarification and asked questions about their own answer and the correct answer. The following excerpt is an example:

Teacher: What is the correct answer?

Students: 25

Student A: (Raised hand, teacher acknowledged student) How come it's not a 9? This doesn't make sense.

The second highest score tallied was under "praises or encourages students" with 81. The observer loved how generous the teacher was in giving praises to his students. Some praises captured during the observations were "Good job!", "Excellent!", "That's right!", and "Good!". On the other hand, the least tallied score was 6 which is under the category where the transition from silence to justifying authority occurred. The observer discussed with the teacher that these six tallies came to how I started and ended my class.

	1	2	3	4	5	6	7	8	9	10	Total
1	42										42
2		81		15							96
3		48									48
4	30		27	54				87			198
5					42						42
6						39	33			36	108
7							30			6	36
8								69			69
9									54		54
10			18			24				63	105
Total	72	129	45	69	42	63	63	156	54	105	798

Legend: Row and column header numberings represent the following
1 – accepts feeling
2 – praises or encourages
3 – accepts ideas
4 – asks questions
5 – lecture
6 – giving directions
7 – criticizes or justifies authority
8 – pupil-talk-response
9 – pupil-talk-initiation
10 – silence or confusion

Table 4. Student Interaction using the Flanders' Interaction Analysis Matrix

Type of Ratio	Anticipated Average Percentage	Observed Average Percentage
Teacher Talk	68%	60.52%
Pupil Talk	20%	26.32%
Silence or Confusion	12%	13.16%

Table 5. Interaction Percentage

The teacher talk in the study was computed to be 60.52%, and the anticipated average for this ratio based on studies is 68%. This percentage means the teacher talked below the expected speaking rate inside the classroom. This result indicates the teacher lived up to being a guide on the side rather than a sage on the stage. Flipping the classroom paved the way for the teacher to deliver only the essentials rather than feeding the students all the information needed to be learned. The students themselves were the ones who discovered learning through practice and exposure to the topics because the teacher provided more activities and games and utilized most of the time by making students answer by themselves, in pairs, and in groups.

Second, pupil talk is 26.32%, whereas the average pupil talk should be 20%. This result, being higher than the average pupil talk, corroborates with the teacher's observation that students were consistently participated actively in activities and games and asked questions.

Third, silence or confusion is 13.16%, whereas the average silence percentage should be between 11% and 12%. The intervention received a percentage above the expected average for students' silence and confusion. In the teacher's journal, he wrote, "Many students have asked more questions in the Flipped classroom than in previous classes he had taught in the traditional class instruction. Most questions were about the process of solving the given items. However, there were still questions that they would not have asked if they only listened attentively. Nonetheless, this is way better than not caring about the course or doing anything. At least they clarified what they missed or where they got confused." The teacher received question after question during the intervention. Students became conscious of their scores and wanted to get excellent scores and not just do tasks for compliance or for them just to pass the course. They have become aware of their grade and even monitored them online almost daily. Although students watched the videos and were exposed more to the topics through activities and games, there were still difficult items on the worksheets that required knowledge of previous topics, combining everything that had been taught and going beyond what was taught. In items like these, students asked for help and listened attentively as the teacher explained or helped them realize what needed to be done.

Student-teacher Interaction

The following are some clarifications students asked on their worksheets.

> *Student A: Where will we write the exponent when transforming the expressions in radical form? Should we write it inside (the radical symbol) with the radicand, or put a parenthesis and the exponent outside?*
>
> *Student B: Do we need to simplify our final answer when we write the expressions from exponential to radical form and vice versa?*
>
> *Student C: What do you prefer for us to write when the radicand with an even index is negative?*
>
> *Student D: Do you want us to simplify them (referring to their final answer) into an integer or a fraction? Or can we have a decimal answer?*
>
> *Student E: Can we write our answer without a solution for some items?*
>
> *[For this item, Student E showed item number 8 to the teacher:* $\left(\frac{8}{15}\right)^0$*]*

Student F: Do you want us to simplify (the student likely asked if they could transform their final answer) our answer to radical form?

Some students needed to remember the rule on negative exponents even if two activities were already given or possibly were just curious about the most efficient way to solve it.

Student D: Can we have a refresher on this?

Student G: If a fraction is raised to a negative exponent, does it matter whether the exponent is odd or even? Is there a rule for that?

Student H: What is the easiest way to answer items like this? Make the exponent positive or distribute the exponent? [5.2BB Activity item #14: $\left(\frac{8^4}{10^4}\right)^{-\frac{1}{4}}$ *]*

Some students asked where to access their online activities and journals.

Student A: So, after we watch the video, where will we answer it (guide questions)?

Student C: The videos are found in Google Classroom, but where's the link for guided questions?

Student G: Do you mean that guided questions differ from the journal?

On the other hand, three (3) students consistently did not interact with their classmates or barely interacted with them during the three observations. These three students did not interact with the teacher as well. Nonetheless, a student remarked: *Student B: Asking for help is good.*

Student-content Interaction

Students' journals were thematically analyzed by the researcher based on very similar responses, the most common answers by many, or answers that occurred more often. According to students, they have utilized the materials provided them, and thought that those were helpful in learning the topics. Students wrote in their journals: "*Used calculator and whiteboard few times,*" "*Available materials made the equation (answering) easier,*" and "*Attended sessions to ask the teacher for help (using basic calculator).*"

DISCUSSION

The study's results led to the crafting of guiding principles in conducting a flipped classroom. The data from the survey for student achievement motivation, number of attempts in MyOpenMath, Chapter Test scores, teacher journal, student journal, observation notes, student-student interaction rubric, and *Flanders' Interaction Matrix* were all analyzed to craft a guide in the conduct of flipped classroom.

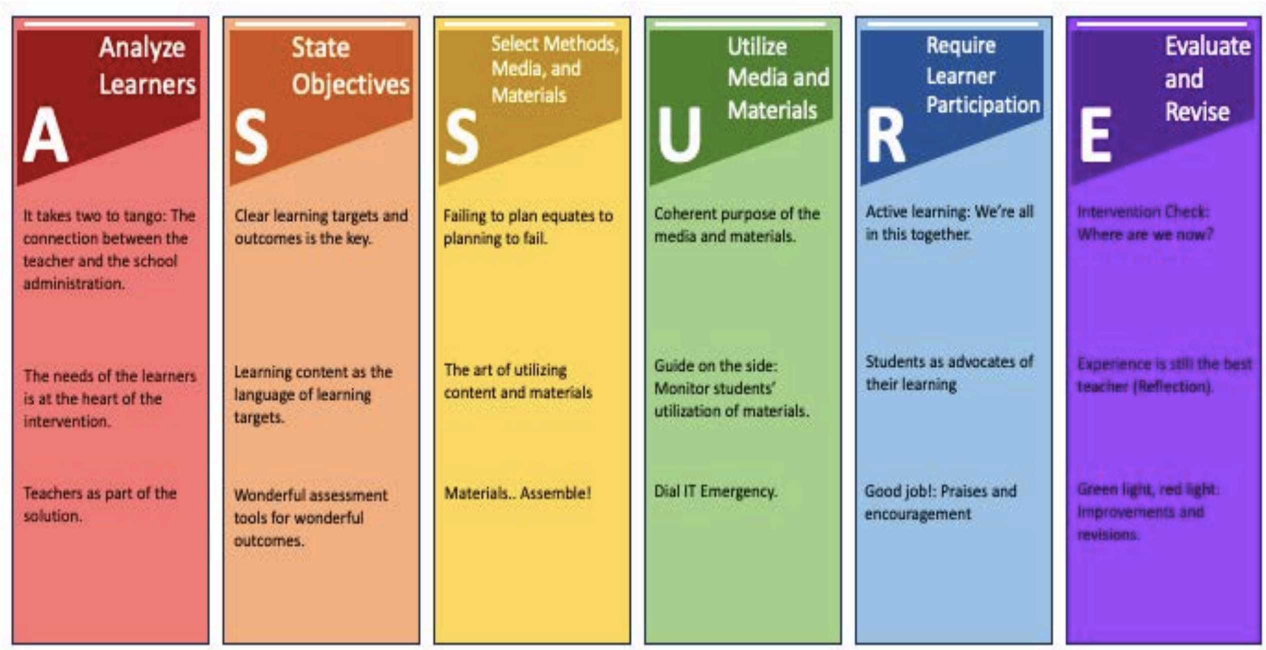


Figure 7. Guiding Principles in conducting Flipped Classroom (Lefebre, 2006)

Figure 7 shows the Guiding Principles for conducting a Flipped Classroom. After the study has been conducted, the guiding principles the researchers considered, and the results drawn from the data are best represented by the ASSURE model. Furthermore, it is a model where education guidelines can be crafted or altered so teachers can benefit from the ever-advancing educational technologies. The model was chosen from the many guides and models presented in studies about blended learning. According to Lefebvre (2006), the ASSURE model, which was developed in 1993 by Heinich, Molenda, and Russell, is an instructional design or guide that merges media and technology for the enhancement of learning environment. It guides teachers to efficiently incorporate technology, media, and materials into their teaching. The six phases under this model are: *Analyze learners*, *State objectives*, *Select methods, media, and materials*, *Utilize media and materials*, *Require learner participation*, and *Evaluate and revise*.

In this study, three significant aspects were considered in each phase in the ASSURE model for successfully conducting a flipped classroom. The researcher created these guiding principles with high regard for the data collected and analyzed. It paved the way for the alteration, verification, and validation of the ASSURE model, an additional contribution to the existing body of literature. The result of the achievement motivation questionnaire before flipping the classroom and the district's response letter regarding ethics and limitations on data acquisition within the district have been the basis for the guidelines on *Analyze Learners*. For the guiding principles under *State Objectives*, the standards of the Nebraska Department of Education and the district were all considered. Also, the *Select Methods, Media, and Materials* guiding principles and *Utilize Media* *and Materials* guiding principles were all anchored on the results of flipping the classroom, MyOpenMath questions, games, activities, daily quizzes, and interaction. For the *Require Learner Participation* guiding principles, the students' journal, student-teacher interaction, and teacher-teacher interaction were all considered. Lastly, the teacher journal, Mathematics Chair observations, and the students' Chapter Test results were the basis of the last guiding principles for the *Evaluate and Revise* strand. Overall, the guiding principles represented through the ASSURE model were based on the study's three constructs: achievement motivation, interaction, and academic achievement.

CONCLUSION AND RECOMMENDATIONS

In the study, achievement motivation became evident during pair and group activities. This study had the same outcome as the study of Maehr (2018), where interactions between and among peers paved the way to be highly motivated in accomplishing activities. As Erdogan et al. (2011, as cited in Afrifa-Yamoah, 2016) explicitly stated, the need for achievement shows itself as a desire to complete a task or behavior according to perfection. This result was evident through incorporating group activities in games where the observer thought it motivated students to do well, as students saw it as a "competitive game." However, there were instances where some students strayed from game instructions to "win" the game. Nevertheless, the observer often remarked that students were very competitive throughout the observations.

Still, the teacher chose games where students were not severely affected psychologically because interaction is a multi-faceted construct (Martin and Rimm-Kaufman, 2015). This remark was supported by the comment given to the Kahoot! presented by the teacher as a "low risk" in that nobody knew which students answered incorrectly and was allowed to address those mistakes at the moment.

In the study of Chin (2006), it was concluded that the issues involving interaction in class – i.e., not all students communicating or responding in class, an issue that needs to be addressed. Many problems regarding communication were solved in this action research because there was less teacher talk, and all sessions were student-centered. Also, there was ample time after the game for students to complete their independent assignments so that their next homework time could be focused on watching the following video and answering the MyOpenMath questions before the next class. During this time, students communicated to the teacher some items they did not know how to solve or asked for clarification.

Many positive outcomes were seen during and after the intervention. However, this does not mean students have yet to experience difficulties discussing the topics. The students have struggled with the last five topics of the chapter, namely simplifying radicals, simplifying variable expressions, rational expressions, complex fractions, and dividing complex numbers. This problem has become evident in the average number of attempts in MyOpenMath and the most common errors in the Chapter 5 Test after conducting the frequent errors.

This action research can improve the provision of an intensive orientation on the MyOpenMath platform by providing students with a video tutorial on a hands-on seminar on using math symbols. In addition, the teacher's knowledge of the encoding and creating items in MyOpenMath can be considered in the next cycle. Moreover, there has been limited to no accountability for students who failed to watch the videos before the class started.

Nevertheless, flipping the classroom was successful. There were positive significant results in students' achievement motivation and interaction. Ultimately, the goal of this study was attained when no student failed their chapter test. In the study, the set of guiding principles was crafted using the ASSURE model as a framework so teachers can benefit more from incorporating interventions involving educational technologies like a flipped classroom.

As with any teaching practice, all endeavors have rooms for improvement, so does this action research. Doing action research with more than one cycle will benefit students more. Additionally, including more respondents in future studies will help generalizations become more reliable. As part of the feedback during observations and student journals, activities should also include those that can be done individually. Some students focus more when they do things on their own. Collaborative activities can benefit students in many aspects, as highlighted in the vast array of literature. However, we should also not invalidate individualized assessments. When using MyOpenMath as a platform, it is good to learn how to maximize its readily available resources and tests, but tailoring your questions is still the best way to cater to your student's needs. The difficulty of items can be adjusted depending on the content standards and where students' knowledge and skills are. With this, teachers must still double-check students' answers, like how they check students' work on paper, because these platforms may not be accurate or consistent in checking answers, especially when the assessments are not simply multiple choice.

Section 11 of the Nebraska State Board of Education Position Statements further supported digital education, ensuring everyone had equitable access to technology and opportunities. We are seeing technological advances every day; a great example of this progress is artificial intelligence (AI). Students can quickly solve math problems using AI technology like Photomath and ChatGPT, as experienced in the study. AI like these can be abused by students when they are not guided properly, but it can help teachers to make students learn more if rules in the use of technology inside the classroom are clear to them (Gustilo et al., 2024). When rules are established, we can make students accountable using such technologies. Teachers and students can harness the affordances technology offer in professional and classroom learning. Thus, the first researcher added to his rules in the syllabus that such technology may not be used unless the teacher affirmatively communicates to students that online tools may be used for a specific task. The teacher will also decide for each task the extent to which students may use online tools.

According to Bathina, B. (2023), blended learning is an educational approach that seamlessly integrates traditional classroom instruction with online learning components. We are living in an unpredictable world. We were all reminded of this when we were all caught unprepared during the pandemic. Harnessing the affordances blended learning bring addresses unprecedented situations where in-person classes are put on hold for whatever reasons, allowing quality learning to occur through online resources and learning platforms. These developments can only happen when more teachers embrace innovation, incorporate these in school, and provide valuable outputs from their experiences during the intervention. Acknowledging the benefits of blended learning also provides students access to our materials at their convenience. On the other hand, teachers need training and support to implement it effectively. Teachers should continue participating in training and professional development to equip with skills and knowledge in incorporating innovation in classes.

Valuable outputs from observations and students as reflected in the results of this study were considered to craft a plan for the next cycle. To begin with, the responsible utilization of gadgets, technology, and online tools, is being considered. Although students used their Chromebook laptops throughout the intervention, it was seen that some students have the tendencies to abuse its utilization, like when a student used his laptop to play chess online instead of participating in the game or when a student used Photomath on his phone to solve for an item in the game. For the next cycle, the teacher must make sure that students' Chromebooks are in their bags and their phones must be placed inside the phone pockets before the class starts. There should be additional rules on the proper use and occasional of technology inside and outside the class. Students can be allowed to use online tools such as Photomath to complete notes if they missed any, solve items on the notes that they failed to jot down or have not copied, or be guided when they forget the processes involved in solving them. However, they should be made aware that these tools are not allowed inside the classroom unless the teacher allows students to use them for appropriate activities.

For a smooth transition from the daily quizzes to games/activities and individualized worksheets, the teacher plans to seek help from the instructional coach in school. This strategy will improve not only the transition from one task to the other but also the quality of teaching. The gaps between and among lessons and activities can enhance instruction delivery through the instructional coach's mentoring, sharing of techniques, and imparting the latest technologies.

The teacher plans to create a presentation for the preliminaries of the games next cycle. This is to avoid repeating essential announcements and pre-game reminders. It will be flashed on the board so everybody can see it. It will include how each pair/group must arrange their working place or what part of the room they are working in. Inconvenient incidents of students, like climbing over their desks to go to the board because their seat is blocking the way or any other hindrances to learning, will be remedied. With this, the teacher also plans to design fun and efficient ways of grouping students to save time.

Lastly, the teacher will implement flipping of the classroom to all of my classes next academic year. This will be equitable to all students where the teacher delivers lessons and will enhance more students' achievement motivation, interaction, and academic achievement.

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