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Flipped Classroom in a Digital Learning Space: Its Effect on the Students' Attitude Toward Mathematics

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Abstract. Mathematical attitudes tend to deteriorate starting at grade 7 level. In this experiment, the impact of flipped learning on the students' declining attitudes toward mathematics have been investigated. The effect of the flipped classroom in a digital learning space was determined by employing a non-equivalent (pretest and posttest) control-group quasi-experimental design. One hundred sixty-six grade 7 university students served as the participants of this study, eighty-three (83) each for the experimental and control groups. The data was gathered using the Attitude Towards Mathematics Inventory (ATMI) composed of four constructs. The results were analyzed by employing the Mann-Whitney U Test, Wilcoxon Signed Ranks test and descriptive statistics. The results revealed that the overall attitude across the four constructs of ATMI for the control group declined significantly while the experimental group maintained their positive attitude after one school year. Also, the participants in the flipped classroom were better than the participants in the control group with regard to the overall ATMI and the construct value, motivation, and enjoyment. It was concluded that the use of a traditional strategy in digital space negatively affects the attitude of the students in mathematics. The flipped classroom was able to address the declining attitude of the secondary students and maintained their joy, motivation, self-confidence, and value of mathematics. Furthermore, this study recommends employing the flipped classroom model in a different mode of learning to improve attitude and academic performance, while improving the sampling technique, and making it the basis of administration of policymaking, facilitating the creation of ATMI using the native language of the country.

Keywords: flipped classroom; attitudes; mathematics; digital learning

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1. Introduction

The outbreak of the Covid-19 pandemic caused the educational sector to shift from face-to-face to virtual and modular learning which negatively affected the student's attitude to learning in turn. The attitude towards mathematics influences and predicts mathematics achievements (Ajisuksmo & Saputri, 2017; Mazana et al., 2019; Soni & Kumari, 2017; Yaratan & Kasapoğlu, 2012). However, several studies suggest that learners at lower grade levels have a positive attitude toward mathematics compared to students at higher levels. Köğce et al. (2009) and Mazana et al. (2019) found that as the students progressed to a higher level of schooling, notably secondary school, their attitude toward mathematics began to deteriorate. Kibrislioglu's (2015) findings show that sixth-grade pupils have a relatively positive attitudes toward mathematics while the majority of secondary learners have a negative one (Joseph, 2013). Hence, it is expected that the students' attitudes towards learning mathematics will deteriorate when the students enter the secondary level of education.

The flipped classroom strategy could improve the overall attitude of the learners. Bergmann and Sams (2014) expounded in their books the many positive attributes of the flipped classroom such as a student-centered classroom, building rapport with the students, deep learning and effective assessment, the opportunity for collaboration, self-paced learning, and many more. A meta-analysis study showed that the flipped classroom can improve the students' learning performance (Akçayır & Akçayır, 2018). A lot of studies regarding the effect of the flipped classroom on mathematics attitude have been conducted at different levels and focused on a range of courses. Self-confidence, motivation value, and enjoyment are commonly used constructs of the Attitude Towards Mathematics Inventory (ATMI). At the tertiary level, the flipped classroom has a positive effect on the four ATMI categories (Turra et al., 2019). At the secondary level, a study showed that the students in the flipped classroom improved their confidence and enjoyment (Esperanza et al. 2016) and overall attitude (Karadag, & Keskin, 2017). It was also found to be more effective compared to the traditional teaching strategy (Casem, 2016). Despite only a few studies having been conducted involving a flipped classroom and attitudes towards mathematics, Hastuti (2020) said that the flipped classroom could foster an active, enjoyable, and student-centered environment.

Based on the literature shown, the ATMI results show a significant decrease during the transition from elementary to secondary level. Furthermore, most of the studies about flipped classrooms and attitudes toward mathematics are set in higher education. Although there are several studies conducted at the secondary level, it is unclear if the flipped classroom could fill in the gap in terms of the significant decline in attitude towards mathematics before the learners enter junior high school, after experiencing high school mathematics for at least a year in digital space. Research must be conducted to determine whether the flipped classroom could still be effective at enhancing or maintaining attitude despite the decreasing trend of the ATMI results based on the literature.

Thus, incorporating the flipped classroom approach into a digital learning space to improve the students' attitudes toward mathematics could fill a gap in the research and contribute to the existing literature. Specifically, the findings of this study will show whether or not the flipped classroom can be an effective strategy to enhance or maintain the ATMI scores of grade 7 university students. If found effective, it could also be used by some teachers who are having trouble keeping their students motivated, who want them to value mathematics, develop their self-confidence, and enjoy learning. In addition, the results of this study will be beneficial to other schools and universities that have struggled implementing effective virtual learning while also being a basis for schools that are still using a modular approach and planning to implement virtual learning in the future. It could be a basis for changing their policies in terms of implementing a/synchronous sessions, the dos and don'ts in virtual learning implementation, and more. Lastly, the model can help many schools be more systematic when teaching virtually.

This study intends to ascertain whether the flipped classroom model is successful at raising or maintaining the students' attitudes. Quantitative data will be collected utilizing a non-equivalent control-group design (pretest and posttest). Quantitatively, the pretest and posttest ATMI scores of the participants were collected from grade 7 university students from Naga City to test the Cognitive-Affective-Social Theory of Learning in Digital Environments (CASTLE) to assess whether social cues in digital resources stimulate social schemata which improves the learners' emotional, metacognitive, and motivational processes.

2. Related Literature

This section discusses the literature on attitude towards mathematics, the flipped classroom model, and the different findings that transpire in the study of these variables. Also, the attitude, theoretical framework and hypotheses are discussed.

2.1 Attitude Towards Mathematics

There have been many types of ATMI used for gauging the attitude of students towards mathematics. They differ in the number of items and the construct being used. Motivation, value, enjoyment, and self-confidence are among the constructs of ATMI (Lim & Chapman, 2013; Tapia & Marsh, 2002). Meanwhile, the Mathematics Attitude Scale (Askar, 1986) is categorized into positive and negative attitudes and has been used in other studies (Kibrislioglu, 2015; Yaratan & Kasapoğlu, 2012). The ATMI's constructs included intrinsic motivation, perceived utility and enjoyment of mathematics, self-confidence in mathematics, and mathematics anxiety (Fennema & Sherman, 1976; Mazana et al., 2019). Despite several choices of ATMI in the literature, Tapia and Marsh (2002) adopted it since it was widely used and had an acceptable Cronbach's alpha.

2.2 Flipped Classroom and Attitude towards Mathematics

There have been a few pieces of research conducted involving flipped classrooms and ATMI compared to flipped classrooms and the academic performance of the students. Tekin and Sarikaya (2020) employed the ATMI of Tapia and Marsh (2004) and found that there was no significant difference before and after carrying out the flipped classroom and technology-integrated face-to-face classroom model among grade 10 students in the city of Tokat in Turkey. The study did not examine the four ATMI components but the students in the flipped classroom had much higher ATMI scores than those in the other model. The same instrument was used by Esperanza et al. (2016) on third-year secondary students in the USA and they looked into the aspects of ATMI. The data gathered showed that the students in the flipped classroom improved regarding the constructs of enjoyment and self-confidence. No significant improvement was found for the value of mathematics and motivation, and employing the traditional classroom in the control group showed a significant decrease in the value of mathematics. Mondragon and Acelajado (2018) discovered no significant differences in the confidence and utility of mathematics using the traditional approach, in contrast.

Turra et al. (2019) adopted an ATMI and employed it with engineering students at Universidad Católica de Temuco, Araucanía Region, Chile. They found that the flipped classroom improve the overall attitude of the students as well as their personal confidence, the usefulness of the subject, their perception of mathematics as a male domain content, and the teacher's attitudes. On the contrary, Casem (2016) found no significant rise in the ATMI score of fourth-year students in the Philippines before and after implementing the flipped classroom model. The four modified Fennema-Sherman subscales, measuring mathematics anxiety, confidence in studying mathematics, attitude towards mathematical achievement, and the teacher's perceptions, all yielded the same results. Another interesting result found in the literature was the comparison between the ATMI posttest result of the control and experimental groups. The ATMI scores of the learners in the flipped classroom were better compared to the scores employing different models or pedagogy (Tekin & Sarikaya, 2020). Meanwhile, most of the students in Fuchs's (2021) qualitative review had a favorable opinion of the flipped classroom, although they had reservations about the added effort for the students, the vagueness of the desired learning objectives, and the initial barrier to actively participating.

Most of the experiments involving a flipped classroom and ATMI have employed on university college students at fourth year and grade 10 level. However, ATMI level does not decline significantly for those age brackets and grade levels. It was shown in the literature that the students' overall ATMI scores decline significantly from primary to secondary and minimally increase from secondary to college. This paper fills in the gap in the literature specifically by looking into the effects of implementing a virtual flipped classroom on the students' ATMI scores, especially at the grade 7 level, where there is a significant ATMI score decline based on the literature.

2.3 Theoretical Framework
This subsection introduces CASTLE as the theoretical grounding of this study and how the concepts of this theory relate to the constructs of the ATMI.

2.3.1 CASTLE
CASTLE serves as the theoretical framework of this study. Here, the social cues in digital resources prompt the learners to activate their social schemata which

improves their emotional, metacognitive, and motivational processes (Schneider et al., 2021). Both the control and experimental groups of this study have consumed rich and high quality digital materials throughout the course since pure online classes were implemented. They have been highly exposed to digital materials in the form of LMS, video lessons/recordings, text, pictures, etc. A broad definition of digital learning materials encompasses anything from simple text and image pairings to interactive media or media that shows information in a time-dependent way, like films or animations. Interactive media also includes simulations, educational games, and online quizzes (Schneider et al., 2021). Hence, the learners in both groups may improve these processes or maintain their high-level scores given how the literature showed there to be a significant decrease in attitude between elementary and secondary learners. Consequently, the improvement of these processes may lead to the improvement of the components of ATMI.

Figure 1: Theoretical Paradigm

The definition of attitude can be categorized into three. One is the multidimensional (Affective, Behavior, and Cognitive). The Tripartite model can be used as the theoretical framework in most studies where attitude can be classified to Zan and Di Martino's three categories (Wen & Dubé, 2022; Zan & Di Martino, 2007). Mazana et al. (2019) used the ABC Model of Attitude with three categories, affect, behavior, and cognition, which are related to the processes of CASTLE. Affect is associated with an emotional process (confidence when doing mathematics), behavior is the way that the learners act or react in relation to a certain object (joy and motivation when doing mathematics) and is related to the motivation process, and cognition is the belief and perception of a certain object (mathematics), related to the metacognition process.

2.3.2 Attitude

A person's learned tendency to react favorably or unfavorably to an object, circumstance, idea or other person is referred to as their attitude (Mazana et al., 2019). Although attitude is an abstract concept, it can be observed in terms of emotion, motivation, and metacognition. Emotion is the way that the learners handle their feelings (self-confidence). Motivation is the driving force or the reason for someone to act in a particular way (Motivation to Learn Mathematics and Enjoyment of Learning Mathematics). Metacognition is the recognition and evaluation of something's significance (Value of Mathematics).

2.3.3 Attitude Aspects

This subsection shows the connection between the attitude constructs of ATMI and the concepts of the proposition of CASTLE.

Emotional

Self-confidence. Confidence is the extent to which the students believe they can handle the challenges of mathematics and achieve a specific level of expertise (Wen & Dubé, 2022). Self-confidence in mathematics is the students' ideas regarding their capacity to learn and perform well in mathematics, as well as their judgments of themselves as mathematics learners (Adelson & McCoach, 2011; Mazana et al., 2019). The mindset that they can perform well inside the classroom will improve their self-esteem. They can actively participate in different activities and share their thoughts and ideas with little hesitation.

Motivation

Motivation. Motivation refers to one's desire to continue learning mathematics and their level of interest in the subject (Tapia & Marsh, 2004). Intrinsic motivation is the desire and interest to learn mathematics (Guy et al., 2015; Mazana et al., 2019). Once the learners are motivated to learn, they will give more than what is expected of them.

Enjoyment. The degree to which the students enjoy practicing, appreciating and learning mathematics is known as the enjoyment of mathematics (Kupari & Nissinen, 2013; Tapia & Marsh, 2004). Enjoyment is the students' satisfaction when solving a mathematics problem as well as their happiness in a mathematics class compared to any other class (Anastasiadis & Zirinoglou, 2022). When the learning environment is nurturing, the learners can enjoy learning mathematics and their feeling of anxiety and fear is less.

Metacognitive

Value of Mathematics. The value of mathematics refers to one's opinion regarding the value, relevance, and utility of mathematics (Tapia & Marsh, 2004). The perceived usefulness of mathematics is the extrinsic utility of the value of mathematics and its applicability to the individual's current and future goals in life (Adelson & McCoach, 2011: Mazana et al., 2019; Yáñez-Marquina & Villardón-Gallego, 2016). If the learners found mathematics useful and determined that it will affect their lives, they will value and give importance to it.

2.4 Hypotheses

With the presence of digital materials in both the flipped and traditional classroom, based on CASTLE, this study proposes that both the experimental and control groups activate social schemata and enhance their motivation, value, enjoyment, and self-confidence in mathematics. In this study, it was expected that neither the experimental nor control groups' attitudes towards mathematics were significantly differed from one another and that both groups would improve or maintain their ATMI scores.

3. Methodology

This section outlines the research's design, the strategy for choosing the participants, the research tool and how it will be examined, as well as the research process and any ethical considerations.

3.1 Research Design

To test the objective hypotheses, quantitative research was used to look at the relationships between the different variables (Creswell & Creswell, 2017). This study used a nonequivalent (pretest and posttest) quasi-experimental control-group design. In quasi-experimental designs, the participants are randomly assigned to levels of a controlled variable of interest with the researcher having only limited (or no) influence over this process (Creswell & Creswell, 2017). However, Danday (2021) used another term concerning the design of his paper. In this study, the flipped classroom intervention was implemented in the experimental group while the traditional lecture teaching strategy was used in the control group.

Experimental Group	0----------------X------------------0
Control Group	0------------------------------------0

Figure 2: Non-Equivalent (Pretest and Posttest) Control Group Design

3.2 Participants

This study has one-hundred hundred sixty-six (166) participants, eighty-three (83) each for the control and experimental groups. The participants were all grade seven university students. They were chosen conveniently to ensure that the pretest of both groups was similar at the beginning of the experiment for all ATMI constructs. A quasi-experimental design normally uses this kind of sampling method (Leavy, 2017). She also mentioned that creating similar scores in the pretest could be done through the process of matching, placing one pair in the control group and the other one in the experimental group.

3.3 Sampling

There are three universities in Naga City and one of them represents the population of this study. In the second phase, convenience sampling was used to ensure that the two groups were comparable before the implementation of the intervention. According to Leavy (2017), there are two stages to cluster sampling. The first is choosing from the preexisting clusters (University), followed by selecting samples from the chosen cluster or including all elements in the cluster. Creswell and Creswell (2017) suggested the use of G* power in the power analysis. In the studies by Casem (2016) and Tekin and Sarikaya (2020), the d-values were .82 and .90, respectively. Using the G* Power software, the actual computed powers were both .81, requiring only twenty-six (26) and twenty-two (22) samples for each group, respectively. One of the disadvantages of oversampling is putting more participants at risk in a clinical study. Conversely, this is not true in research in education and the social sciences. To further verify the computed power, Power and Precision 4 software was used. The computed power using eighty-three samples for both groups was 1.00. This is close to 100% and yields a significant effect.

3.4 Research Instrument

This study adopted Tapia and Marsh's Attitudes Toward Mathematics Inventory (ATMI) (2002). The same instrument was used for the pretest and posttest. The

ATMI is a list of statements about the attitudes towards mathematics and is comprised of 40 items on a Likert scale. The 40-item questionnaire measures four constructs: self-confidence (15 items), motivation to learn mathematics (5 items), value of mathematics (10 items), and enjoyment of mathematics (10 items). The questions had a Cronbach's alpha coefficient interval ranging from .88 to .95. Since the instrument was adopted from another country, the interval of the internal consistency in Naga City was tested and ranged from .85 to .97 with an overall of .98.

3.5 Data Analysis

This study employed SPSS version 20 to analyze the quantitative data and the Mann-Whitney U and Wilcoxon-Signed Rank tests to check for differences in the scores between and within groups, respectively. The value of (r) was used to estimate the effect size of the parametric test. Specifically, Glass rank-biserial correlation for the Mann-Whitney U-statistic test and rank-biserial correlation for the Wilcoxon signed ranks test (Tomczak & Tomczak, 2014). The r-values were converted to d-values (Ellis, 2010) and classified as d (.01) = very small, d (.2) = little, d (.5) = medium, d (.8) = large, d (1.2) = very large, and d (2.0) = huge when interpreted using the updated rules of thumb for effect sizes (Sawilowsky, 2009). The conversion formulas are listed below.

$$\boldsymbol{d} = \frac{\boldsymbol{2r}}{\sqrt{\boldsymbol{1-r^2}}} \qquad\qquad \boldsymbol{r} = \frac{\boldsymbol{d}}{\sqrt{\boldsymbol{d^2+4}}}$$

3.6 Procedures and Ethics

This study was conducted during the academic year 2021 - 2022. The first step that the researcher did was to seek the permission of the school to conduct the research. A consent letter was sent to the parents of the participants, then the pretest was conducted afterward using Google Forms. The researchers monitored the teacher's implementation of the intervention to ensure that the model was properly executed. At the end of the school year, a posttest of the ATMI was conducted using the same platform and the researcher ensured that the identity of the participants would remain confidential. Lastly, the results were reported to the teachers and administrators of the three universities in Naga City. Figure 3 shows the flipped classroom model in online learning that was implemented in this study (Romero & Angeles, 2021). The intervention implemented in this study is the flipped classroom strategy. This is an inverted classroom in which out of class time is maximized to help the students learn the necessary concepts. Meanwhile, the in-class time is used for mastery and in-depth learning.

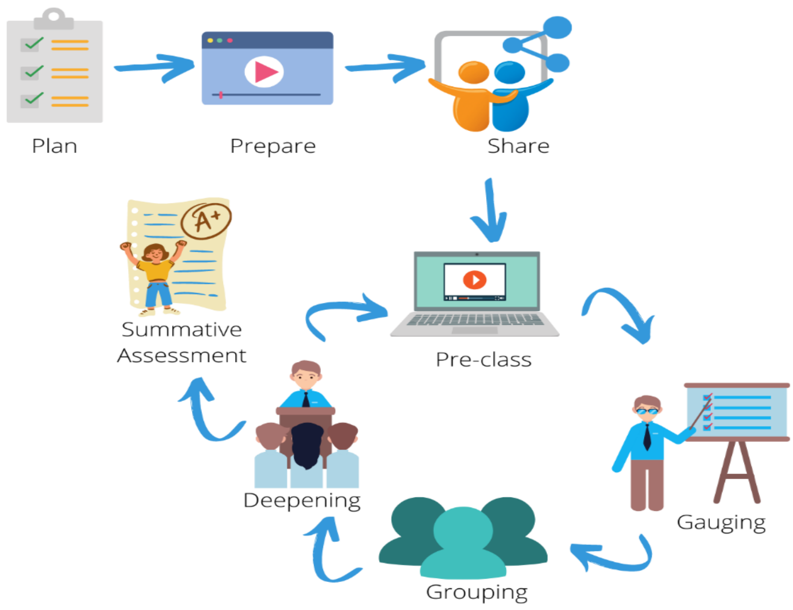

Figure 3: Flipped Classroom Model

4. Results

This section contains the findings following the analysis of the data. The tables present the pretest and posttest results as well as the results between the two groups.

4.1 Pre-study Attitudes Towards Mathematics

Before beginning the intervention, a pretest looking into the participants' attitudes towards mathematics was given on the first day of the school year. As can be seen, the Attitude Towards Mathematics Inventory (ATMI) has a maximum score of five (5) points and a minimum score of one (1). According to Table 1, the experimental group (Mn=3.46, 69.2%) performed lower than the control group (Mn=3.48, 69.6) in terms of the test scores. When the median scores were examined, the same outcome was seen.

Table 1: Results of the ATMI's Pretest

Test/Group	*N*	*Md (Max=5)*	*Mn (Max=5)*	*SD*
Pretest				
Experimental	83	3.38(67.6%)	3.46(69.2%)	.592
Control	83	3.57(71.4%)	3.48(69.6%)	.623
Total	166	3.45(69.0%)	3.51(70.2%)	.609

It was shown that the control group had higher scores for both the mean and median comparison. However, the pretest scores from Table 2 show that there was no difference (p=.357) and that the effect size (r=.08) was very small. This shows that prior to participating in the study, the experimental and control groups were similar.

Table 2: Pretest ATMI - Mann-Whitney U test

Test/Group	*N*	Mean Rank	Mann-Whitney U	Z	P	r(ES)
Pretest						
Experimental	83	80.07	3159.50	-.921	.357	.08
Control	83	86.93				

*Note: *p<.05; **p<.01*

The pretest results for the four attitudes towards mathematics constructs are shown in Table 3. In terms of motivation, value, enjoyment, and self-confidence, the control group outperformed the experimental group by a small margin. Given how the p-values (p=.412, p=.600, p=.181, and p=.297) were higher than p=.05, there were no differences between the group scores for any of the constructs with a very small effect size (*r=.07, r=.05, r=.09*) and small effect size (*r=.12*). This outcome demonstrates that before participating in the study, the two groups' attitude towards the mathematics constructs were almost equivalent.

Table 3: Pretest of the ATMI Constructs - Mann-Whitney U test

ATMI Component	Experimental		Control					
	Mn (Max=5)	Mean Rank	Mn (Max=5)	Mean Rank	M-W-U	Z	p	r(ES)
Motivation	3.32(66.4%)	80.46	3.44(68.8%)	86.54	3192.0	-.82	.412	.07
Value	4.07(81.4%)	81.55	4.13(82.6%)	85.45	3282.5	-.53	.600	.05
Enjoyment	3.46(69.2%)	78.52	3.57(71.4%)	88.48	3031.0	-1.34	.181	.12
Self-Confidence	2.99(59.8%)	79.61	3.14(62.8%)	87.39	3122.0	-1.04	.297	.09

*Note: *p<.05; **p<.01*

4.2 Results for the Attitude Towards Mathematics Inventory (ATMI) Posttest

One day after the intervention, the Attitude Towards Mathematics Inventory (ATMI) was administered as a posttest. Table 4 displays the mean, median, and standard deviations. This time, an opposite result occurred where the experimental group gained higher mean and median scores (*Mn=3.48, 69.6%; Md=3.48, 69.6%*) compared to the control group (*Mn=3.24, 64.8%; Md=3.24, 64.8%*). Also, the experimental group got a lower standard deviation (*SD=.46*) compared to the control group (*SD=.52*). This demonstrates that the experimental group's scores were closer than those of the control group's members.

Table 4: Posttest Results of the ATMI

Test/Group	*N*	*Md (Max=5)*	*Mn (Max=5)*	*SD*
Posttest				
Experimental	83	3.48(69.6%)	3.48(69.6%)	.46
Control	83	3.24(64.8%)	3.24(64.8)	.52
Total	166	3.38(67.6%)	3.36(67.2%)	.50

The impact of the intervention on the overall attitude toward mathematics was evaluated using the Wilcoxon Signed Ranks test. It compared the results of the groups' pretest and posttest. Table 5 exposed that, with a very small effect size (r=.04), the experimental group only slightly improved their posttest scores compared to their pretest scores (p=.728). Conversely, the posttest scores of the participants in the control group, significantly (p=.000) and with a very large effect size (r=.50), declined in relation to their pretest scores. This reveals that there has been considerable deterioration in the participants' attitude in the control group.

Table 5: Wilcoxon Signed Ranks Test Overall ATMI of Two Groups

Group	N	Z	p	r(ES)
Experimental	83	-.347	.728	.04
Control	83	-4.08	.000**	.50

*Note: *p<.05; **p<.01*

To determine the effect of the interventions on the participants' attitudes toward mathematics, further analysis was done. The difference between the two groups' posttest results were examined using the Mann-Whitney U test. With a medium effect size (r=.27), Table 6 revealed that individuals in the experimental group had a higher mean score (p=.002) than the control group. This suggests that the intervention implemented in the experimental group was better than that in the control group.

Table 6: Posttest ATMI Mann-Whitney U test

Test/Group	*N*	Mean Rank	Mann-Whitney U	Z	p	r(ES)
Posttest						
Experimental	83	94.83	2504.00	-3.04	.002**	.27
Control	83	72.17				

*Note: *p<.05; **p<.01*

The mean scores of the two groups for each construct of the ATMI are shown in Table 7. It clearly shows that the mean scores of the participants in the experimental group across all constructs (*3.42, 68.4; 3.99, 79.8; 3.51, 70.2; 3.0, 60.0*) were higher than those of the control group (*3.03, 60.6; 3.85, 77.0; 3.25, 65.0; 2.85, 57.0*). This suggests that in every ATMI construct, the experimental group outperformed the control group.

Table 7: Constructs of the ATMI Posttest

ATMI Component	**Experimental**	**Control**
	Mn(Max=5)	**Mn(Max=5)**
Motivation	3.42(68.4%)	3.03(60.6%)
Value	3.99(79.8%)	3.85(77.0%)
Enjoyment	3.51(70.2%)	3.25(65.0%)
Self-confidence	3.00(60.0%)	2.85(57.0%)

The pretest and posttest scores of the two groups for each construct were compared by employing the Wilcoxon Signed Ranks test. It is revealed in Table 8 that the control group obtained significantly lower mean scores across all constructs (*p=.000, p=.000, p=.000, p=.018*). The effect sizes for motivation, value, and enjoyment were large (*r=.40, r=.47, r=.46*) while there was a medium effect size (*r=.27*) found for self-confidence. On the contrary, the differences before and after the implementation of the intervention across all constructs (*p=.123, .235, p=.812, p=.746*) were not significant in the experimental group. The effect sizes for motivation and value were small (*r=.18, r=.14*) while they were very small for enjoyment and self-confidence (*r=.03, r=.04*). Hence, it could be assumed that the intervention made in the experimental group is effective at maintaining the positive attitude of the participants.

Table 8: Per Construct of the ATMI Wilcoxon Signed Ranks Test

ATMI Component	Group	N	Z	P	r(ES)
Motivation	Experimental	83	-1.543	.123	.18
	Control	83	-4.229	.000**	.40
Value	Experimental	83	-1.188	.235	.14
	Control	83	-4.145	.000**	.47
Enjoyment	Experimental	83	-.238	.812	.03
	Control	83	-3.661	.000**	.46
Self-confidence	Experimental	83	-.324	.746	.04
	Control	83	-2.369	.018*	.27

*Note: *p<.05; **p<.01*

The posttest was compared between the two groups using the Mann-Whitney U test in line with the ATMI constructs. The experimental group's mean ratings for motivation, value, and enjoyment were seen to be significantly higher (p=.000, p=.04, and p=.046), whereas self-confidence was greater but not significantly so (p=.161). Furthermore, the effect size for motivation was large (r=.40) and small along with value, enjoyment, and self-confidence (r=.18, r=.18, r=.13). Except for the self-confidence construct, it could be assumed that the experimental group's intervention performed better than the control group's intervention.

Table 9: Per Construct of the ATMI Posttest Mann-Whitney U test

ATMI Component	Group	Posttest			
		Mean Rank	M-W-U	P	r(ES)
Motivation	Experimental	100.25	2054.00	.000**	.40
	Control	66.75			
Value	Experimental	91.14	2810.50	.04*	.18
	Control	75.86			
Enjoyment	Experimental	90.93	2828.00	.046*	.18
	Control	76.07			
Self-confidence	Experimental	88.72	3011.50	.161	.13
	Control	78.28			

*Note: *p<.05; **p<.01*

5. Discussion

The results show that after one year of using a traditional classroom strategy at the secondary level, all constructs and the control group's overall attitude toward mathematics drastically declined, especially the constructs of motivation, value, and enjoyment where the effect sizes are large. Esperanza et al. (2016) found that the value of mathematics among the students exposed to traditional lessons declined significantly. Conversely, the flipped classroom model implemented in the experimental group maintained a positive attitude toward mathematics among the participants across all constructs of ATMI as well as overall attitude. The studies by Köğce et al. (2009), Mata et al. (2012), and Mazana et al. (2019) revealed that as the students get to a higher level in school, their attitude toward mathematics deteriorates. Also, Kibrislioglu (2015) found that sixth grade students have a relatively positive attitude towards mathematics while secondary students have a negative attitude (Joseph, 2013). Lastly, Casem (2016) found there to be no significant increase in the ATMI score of fourth-year students before and after implementing the flipped classroom model. These findings show that the flipped classroom intervention is effective at maintaining a positive attitude toward mathematics among the participants compared to the traditional strategy teaching in a digital space.

Additional intriguing findings indicated that the control group's overall pretest score, which took into account the four ATMI constructs, was marginally higher than that of the experimental group. The experimental group posttest revealed that overall ATMI, motivation, value, and enjoyment were significantly higher than that of the control group. Even though, between the two groups, the difference was not statistically significant in terms of self-confidence, the experimental group scored higher. Interestingly, the effect size on the motivation construct is large. These results are consistent with what Tekin and Sarikaya (2020) found in their investigation, where they declared that the flipped classroom was better compared to employing a different model of pedagogy and that the flipped classroom was more effective at improving the attitude towards mathematics compared to a traditional teaching strategy (Casem, 2016). The findings manifested that a flipped classroom is a better strategy compared to a traditional classroom for improving the student’s attitude towards mathematics in a virtual setting. Since attitude towards mathematics predicts academic performance (Yaratan & Kasapoğlu, 2012; Soni & Kumari, 2017; Ajisuksmo & Saputri, 2017; Mazana et al., 2019), the flipped classroom could potentially improve the academic performance of the learners.

6. Conclusions and Recommendations

It could be inferred that the participants in the flipped classroom are motivated and enjoyed learning mathematics compared to the traditional strategy. The traditional strategy negatively affects the attitude of the students and makes them less motivated, lowering their self-confidence, making them bored and value mathematics less. In addition, the flipped classroom addressed the declining attitude in mathematics among secondary learners, particularly in grade seven. The findings of this study refute the CASTLE which postulates that social cues in digital materials activate social schemata in learners leading to enhance metacognitive, emotional, and motivational processes. Thus, the significant decrease in the four constructs of ATMI was only observed in the control group which means that there was a significant decline in the participants' motivational, emotional, and metacognitive processes. It is suggested that social cues in digital materials alone do not ensure social schemata activation, and that the use of an appropriate strategy on how to use these digital materials is a big factor. The findings of the study imply that teachers must adapt to education 4.0 practices such as the flipped classroom strategy to maintain a positive attitude towards mathematics among the learners, improving their mathematics proficiency.

Furthermore, the findings of this study suggest the modification of the CASTLE. Specifically, digital social cues and effective and appropriate teaching strategies help learners activate their social schemata which improves their emotional, metacognitive, and motivational processes. Thus, this paper recommends replicating this study in a digital space, face-to-face settings, and hybrid learning spaces using the model of a flipped classroom as well as implementing the model in several schools/universities to ensure the generalizability of the findings, applying the model to improve the academic performance of the learners. Also, creating the ATMI using the student's native language is highly recommended to remove the language barrier, especially for young learners. To the administrators, it is recommended to ensure that asynchronous time is given to the learners regardless of the mode of learning applied and ensuring the readiness of the teachers when implementing the flipped classroom.

6.1 Limitations and Future Research

This study found several limitations. A manipulation check measure was not implemented in this study which could have added the comparison of the control and experimental groups using other factors related to ATMI prior to conducting this study. Also, to ensure that the two groups were comparable, random sampling was not used when determining the participants. Hence, removing the bias in the selection of the participants is not ensured. Although the ATMI used in this study had an acceptable Cronbach's alpha, choosing the best ATMI (better Cronbach's alpha, shorter in terms of the number of items, etc.) available is another limitation. Lastly, this study does not further explain the quantitative results using a qualitative database such as engaging with a mixed-method experimental core design. To confirm that the two groups are comparable, researchers may replicate this investigation in future studies with better results by using manipulation check measures before administering the pretest. These measures could include motivation inventories, emotional intelligence constructs, and other measurements that are related to the attitudes toward mathematics. Furthermore, it is strongly encouraged to use ATMI with a higher reliability score and qualitative database.

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APPENDIX 1: Guide to using the Flipped Classroom Model

Stage 1: Plan

The teacher plans the number of days allotted for each competency, the activity, and strategy used, and the number of summative assessments, quizzes, and worksheets.

Stage 2: Prepare

The teacher creates and chooses the video lessons, modules, learning packages, quizzes, summative tests, anecdotal records, formats for the tentative grades, mini tasks and performance tasks, worksheets, LMS, and other learning materials needed.

Stage 3: Share

The teacher distributes the learning package and shares the video lesson via Youtube and other learning resources through LMS.

Stage 4: Pre-class

The students are expected to utilize the materials provided by the teacher and complete the activity at the end of the video lesson.

Stage 5: Gauging

The teacher assesses the students' learning and understanding and makes sure that all students grasp the lesson and the problem given.

Stage 6: Grouping

The teacher creates a venue for the learners to collaborate, practice, master the lessons, then plan and prepare for the deepening stage.

Stage 7: Deepening

The teacher assesses the students' mastery and in-depth understanding of the lesson.

Stage 8: Summative Assessment

The teacher gives a test after each term or chapter.

APPENDIX 2: The adopted ATMI.

Directions: This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Darken the circle that most closely corresponds to how the statements best describes your feelings. Use the following response scale to respond to each item.

PLEASE USE THESE RESPONSE CODES:
A – Strongly Disagree, B – Disagree, C – Neutral, D – Agree, E – Strongly Agree

1. Mathematics is a very worthwhile and necessary subject.
2. I want to develop my mathematical skills.
3. I get a great deal of satisfaction out of solving a mathematics problem.
4. Mathematics helps develop the mind and teaches a person to think.
5. Mathematics is important in everyday life.
6. Mathematics is one of the most important subjects for people to study.
7. High school math courses would be very helpful no matter what I decide to study.
8. I can think of many ways that I use math outside of school.
9. Mathematics is one of my most dreaded subjects.
10. My mind goes blank and I am unable to think clearly when working with mathematics.
11. Studying mathematics makes me feel nervous.
12. Mathematics makes me feel uncomfortable.
13. I am always under a terrible strain in a math class.
14. When I hear the word mathematics, I have a feeling of dislike.
15. It makes me nervous to even think about having to do a mathematics problem.
16. Mathematics does not scare me at all.
17. I have a lot of self-confidence when it comes to mathematics
18. I am able to solve mathematics problems without too much difficulty.
19. I expect to do fairly well in any math class I take.
20. I am always confused in my mathematics class.
21. I feel a sense of insecurity when attempting mathematics.
22. I learn mathematics easily.
23. I am confident that I could learn advanced mathematics.
24. I have usually enjoyed studying mathematics in school.
25. Mathematics is dull and boring.
26. I like to solve new problems in mathematics.
27. I would prefer to do an assignment in math than to write an essay.
28. I would like to avoid using mathematics in college.
29. I really like mathematics.
30. I am happier in a math class than in any other class.
31. Mathematics is a very interesting subject.
32. I am willing to take more than the required amount of mathematics.
33. I plan to take as much mathematics as I can during my education.
34. The challenge of math appeals to me.
35. I think studying advanced mathematics is useful.
36. I believe studying math helps me with problem solving in other areas.
37. I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in
math.
38. I am comfortable answering questions in math class.
39. A strong math background could help me in my professional life.
40. I believe I am good at solving math problems.