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Freeing the Formula: Liberating Learners from Math Stress Limitations

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Abstract

Mathematics is one of the core subjects in school that students must excel with. Still, they get easily anxious about it which ends up messing with how well they do in the learning area. In this regard, the particular study looked into whether certain learner-focused methods that can help reduce Math anxiety and therefore, boost performance when it comes to scientific notation for Seventh Graders. Strategies they tried included the flipped classroom approach, gamified learning, and the usage of manipulatives. Eventually, they went with a mixed-methods setup for the research which meant pulling data from 88 students using MATH-EASE tool, plus pretests, posttests, and even some focused group chats. From the start, anxiety levels came out pretty low to average overall. But the big issues turned out to be how tough the content felt and the mental load it put on everyone. So, they customized the interventions based on these findings. In terms of writing and converting numbers, they combined flipped classrooms with manipulatives. In the same manner, doing operations were gamified learning paired with manipulatives too. After all these procedures, the posttest results showed real progress: conversions hit an outstanding level; operations got up to fairly satisfactory. Paired-sample t-tests backed it up with significant improvements, with p less than 0.01. In summary, anxiety dropped from 2.36, which is minimal, down to 1.51, without anxiety at all. Additionally, students' feedback in the discussions lined up with this. They talked about feeling more confident, getting more engaged, and not scared of making mistakes anymore. Pretty much, these interactive, student-centered ways not only help with better scores, however, they also build a more positive vibe around Math in general.

Keywords: *Math anxiety, Flipped classroom, Manipulatives, Gamification, Grade 7 mathematics*

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I. INTRODUCTION

Math is one of the key subjects students take persistently in high school. It builds fundamental concepts for college preparation and figuring out real life problems. The thing is, lots of students experience Math anxiety as their learning progresses. It messes with their confidence and drive, and their grades too. Ashcraft back in 2002 and Beilock in 2008 talked about this claim that anxiety ramps up especially with those abstract ideas or when the brain work gets intense. In addition, even though old school teachings involve drills memorization over and over. Hembree noted that in 1990, and Ramirez and others in 2018 backed up this conclusion.

Teachers have been trying out effective ways to fix this. They go for student focused methods that get kids involved, let them take charge a bit, and really grasp the concepts. For instance, in flipped classroom ideas, students handle the basics on their own time, until then class becomes all about talking and working together (Bergmann and Sams, 2012). Then there's gamification. It mixes in games, team work, and setting goals to keep motivation high. Hamari and team looked at that in 2014. Meanwhile, manipulatives are another tool, which make those tough abstract things feel real, that people can touch them, so the mental load lightens up (Furner, 2024).

Past research confirmed these claims one by one. But not much has dug into what happens when you combine them. Especially for tackling both anxiety and how kids do on scientific notation. That's a basic topic, but it trips up a lot of seventh graders. So, this study looked at flipping the classroom along with gamification and manipulatives all together. The goal was to boost achievement and cut down anxiety in Math.

Objectives of the Study

This study aimed to:

1. Identify the sources of anxiety in learning Mathematics among Grade 7 students;
2. Implement strategic interventions to reduce learners' anxiety in Mathematics;
3. Determine the pretest and posttest performance of students in:
    a. Writing and converting numbers in scientific notation;
    b. Performing operations on numbers expressed in scientific notation;
4. Examine whether there is a significant difference between pretest and posttest scores after the interventions;
5. Assess the effectiveness of the interventions in reducing learners' anxiety in learning Mathematics;

II. MATERIALS and METHODS

Research Design

The study went with a convergent mixed-methods approach including quantitative and qualitative methods. In doing so, this helped put together a more complete view of how those interventions as children affected with Math anxiety with their achievement levels.

Participants and Setting

The study happened at Marc Ysrael B. Bernos Memorial National High School, in Abra, Philippines. We had 88 Grade 7 students from two full classes who served as the participants.

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For Competency 1, they tried out a flipped classroom setup using manipulatives. For Competency 2, it was gamified learning with those same manipulatives.

Instruments

To check Math anxiety levels, the researcher used MATH-EASE scale. It's a 40-item tool based on Likert responses, covering five main parts. The reliability check came out with a Cronbach's alpha of 0.87, which is solid. For academic achievement, there was a validated test with 30 items, matched up to Grade 7 Math standards.

Procedure

The research broke down into three main phases: First came the pre-intervention like baseline tests and some interviews; Second, came intervention phase that rolled out the strategies; Finally, post-intervention wrapped it up with posttests and more interviews. At the same time, the researcher considered ethical rules too by getting informed consent from parents, students, and school administrators.

Data Analysis

Quantitative data were analyzed using descriptive statistics and paired-sample t-tests at 0.01 significance level. Qualitative data underwent thematic analysis with triangulation for trustworthiness.

III. RESULT and DISCUSSION

Objective 1: Identify the sources of Mathematics anxiety

Table 1 shows that content difficulty (M = 2.41) and cognitive load and application challenges (M = 2.42) were the greatest sources of anxiety, both falling in the "Average Anxiety" range. Other components, including performance anxiety, time pressure, and group/social dynamics, were rated as "Minimal Anxiety".

Table 1. Sources of Mathematics Anxiety (Baseline MATH-EASE Scores)

Anxiety Component	Mean	Interpretation
Theme 1: Performance Anxiety	2.37	Minimal Anxiety
Theme 2: Time Pressure	2.31	Minimal Anxiety
Theme 3: Group and Social Dynamics	2.30	Minimal Anxiety
Theme 4: Content Difficulty	2.41	Average Anxiety
Theme 5: Cognitive Load and Application Challenges	2.42	Average Anxiety
Overall Mathematics Anxiety	**2.36**	Minimal Anxiety

Legend:

4.21 – 5.00	Very High Anxiety
3.61 – 4.20	High Anxiety
2.41 – 3.60	Average Anxiety
1.81 – 2.40	Minimal Anxiety
1.00 – 1.80	No Anxiety

Baseline findings indicate that abstract content and high cognitive demands were the strongest anxiety triggers for students. This supports Ashcraft (2002) and Hembree (1990), who

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Volume 2 Issue 4 (2026)

emphasized that complexity in Mathematics tasks heightens anxiety more than external pressures such as time or group work.

Objective 2: Implement strategic interventions

Two interventions were implemented: (1) flipped classroom with manipulatives for Competency 1 (conversion of numbers in scientific notation), and (2) gamified learning with manipulatives for Competency 2 (operations on numbers in scientific notation).

Table 2. Axial Coding and Strategic Intervention

Axial Coding Theme	Strategic Intervention
Performance Anxiety	Flipped Classroom + Manipulatives
Time Pressure	Gamified Learning + Manipulatives
Group and Social Dynamics	Gamified Learning + Manipulatives (team games lessen anxiety)
Content Difficulty	Flipped Classroom + Manipulatives (visual, step-by-step learning)
Cognitive Load and Application Challenges	Gamified Learning + Manipulatives (breaking tasks into small, gamified parts)

These strategies targeted the specific sources of anxiety identified earlier. Flipped learning provided flexibility and advanced preparation (Bergmann & Sams, 2012), while gamification enhanced motivation through interactive activities (Hamari et al., 2014). The use of manipulatives in both approaches reduced cognitive burden by making abstract concepts concrete (Furner, 2024).

Objective 3: Determine students' pretest and posttest performance

Table 3 shows achievement improved significantly after the interventions. The overall mean rose from 73.71 (Did Not Meet Expectations) to 84.91 (Satisfactory/Very Satisfactory). Gains were greater in Competency 1 (conversion, +15.30) compared to Competency 2 (operations, +7.10).

Table 3. Pretest and Posttest Performance of Students

Competency	Pretest Mean	Posttest Mean	Gain	Interpretation (Posttest)
Conversion (Flipped + Manip)	77.94	93.24	+15.30	Outstanding
Operations (Gamified + Manip)	69.48	76.58	+7.10	Fairly Satisfactory
Overall	73.71	84.91	+11.20	Satisfactory–Very Satisfactory

Legend:

90 and above	Outstanding
85 – 89	Very Satisfactory
80 – 84	Satisfactory
75 – 79	Fairly Satisfactory
74 and below	Did Not Meet Expectations

The pretest revealed students particularly struggled with operations, echoing Liu and Stapleton (2014) and Kazemi and Stipek (2001), who noted that abstract mathematics is difficult without a strong foundation. After interventions, substantial gains were evident, especially in Competency 1. These outcomes support Boaler (2016) and Bergmann and Sams (2012), who showed that student-centered and hands-on strategies boost engagement and mastery. They also

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reflect Constructivist and Self-Determination theories, where active learning and autonomy enhance confidence and performance.

Objective 4: Examine significant differences between pretest and posttest scores

Paired-sample t-tests confirmed that posttest scores were significantly higher than pretest scores across both competencies ($p < 0.01$).

Table 4. Matrix Showing the Significant Difference Between the Pretest and Posttest of the Grade 7 Students

Strategy	Pretest	Posttest	Mean Difference	t-prob	Sig
Strategy 1: Flipped Classroom with Manipulatives	77.94	93.24	15.30	32.754	.000**
Strategy 2: Gamified Learning with Manipulatives	69.48	76.58	7.09	34.961	.000**
Overall	**73.71**	**84.91**	**11.10**	**33.857**	**.000****

**The mean difference is significant at 0.01 level

The statistical confirmation demonstrates that performance gains were not due to chance but attributable to the interventions. This supports Hiebert and Grouws (2007), who emphasized that active teaching methods significantly improve learning outcomes. The evidence indicates that the interventions had a reliable and measurable impact on students' achievement.

Objective 5: Assess the overall effectiveness of interventions in reducing anxiety

Table 5 shows significant decreases in all anxiety components ($p < 0.01$). The overall mean dropped from 2.36 (Minimal Anxiety) to 1.51 (No Anxiety), with the largest reductions of 0.90 points in content difficulty and cognitive load.

Table 5. Matrix Showing the Significant Difference Between the Pre- and Post-Survey on the Level of Mathematics Anxiety in Grade 7

Anxiety	Before	After	Mean Difference	t-prob	Sig
Theme 1: Performance Anxiety	2.37	1.51	0.86	18.870	.000**
Theme 2: Time Pressure Anxiety	2.31	1.50	0.81	16.425	.000**
Theme 3: Group and Social Dynamics	2.30	1.50	0.80	17.036	.000**
Theme 4: Content Difficulty	2.41	1.51	0.90	18.269	.000**
Theme 5: Cognitive Load and Application Challenges	2.42	1.52	0.90	19.842	.000**
Overall Anxiety	**2.36**	**1.51**	**0.85**	**18.441**	**.000****

**The mean difference is significant at 0.01 level

Interventions substantially reduced anxiety across all components, with the greatest improvements in content difficulty and cognitive load. This suggests manipulatives and student-centered strategies helped make abstract concepts more concrete and reduced mental effort. These findings align with Hembree (1990), Beilock and Maloney (2015), and Bieg et al. (2015), who emphasized the role of supportive learning environments in lowering Mathematics anxiety. They also reflect Constructivist and Self-Determination theories, showing that autonomy, competence, and collaboration strengthen both confidence and performance.

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IV. CONCLUSION

The study revealed Grade 7 students initially experienced Mathematics anxiety at minimal to moderate levels, particularly in content difficulty and cognitive load. After the integration of flipped classroom, gamification, and manipulatives, students demonstrated improved performance in scientific notation and a significant reduction in anxiety. These results confirm that learner-centered and interactive strategies are effective not only in enhancing academic achievement but also in fostering more positive attitudes toward mathematics.

V. RECOMMENDATION

Based on the findings, following are recommended:

1. Teachers might want to mix in some interactive, hands-on activities, and ways that put students right in the center of Math lessons during regular classes;
2. Schools ought to set up training sessions for teachers on things like flipped learning, using manipulatives, and those gamified methods too;
3. It makes sense to check in on students' Math anxiety regularly by rolling out support like peer mentoring programs, counseling options, and creative activities in helping out;
4. For Future Research: It is suggested to investigate long-term effects of these interventions and examine their impact on other grade levels and mathematical competencies.

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