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# Investigating the Use of Mathematics Games and a Second Mathematics Class for Struggling High School Students

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**Abstract:** Only one-third of middle school students in Hawai‘i demonstrated proficiency in grade-level mathematics in 2019. This means that most students enter high school without a strong knowledge of foundational mathematics concepts that are essential for success in high school mathematics courses. This case study investigated two instructional intervention tools designed to help high school students who were struggling in mathematics strengthen their knowledge of and skill in foundational mathematics content. This study utilized two intervention tools, a double dose program where students received two full periods of mathematics instruction, and conceptual mathematics games. The tools were implemented to ninth grade students in a mathematics classroom at private high school in Honolulu, Hawai‘i. The primary focus of the study was to investigate the effects of the intervention tools on progress monitoring assessment scores for struggling learners. However, this study also investigated the effects on the assessment scores for non-struggling learners. While the findings showed that the use of games had a positive effect on scores for struggling learners, the double dose program did not show strong positive results for either struggling or non-struggling students. Implications for a future study are to analyze scores on games and observe the conditions of the supplementary course to investigate the effect on assessment scores.

**Keywords**: *Double Dose;* M*athematics; Games.*

## Introduction

In addition to being essential for success in academics, proficiency in mathematics can help students experience career success and, ultimately, is a fundamental skill for success in life. A lack of skill in and knowledge of mathematics could adversely affect an individual’s ability to make important educational, career, and life choices (Hwa, 2018; Kiili & Ketamo, 2018). Thus, helping students develop a strong foundation in mathematics is crucial for progression into and success in high-level mathematics coursework and beyond.

### Statement of the Problem

Due to the hierarchical nature of mathematics, proficiency in mathematics is dependent upon a student being proficient in previous content or skills (Katz, 2015). In order to experience success in secondary and postsecondary mathematics courses, students must have developed a strong understanding of foundational skills learned at lower grade levels (Hwa, 2018; Ketterlin-Geller et al., 2008). The challenge at the high school level is that many students leave the middle grades without the strong foundational skills upon which subsequent mathematics courses, such as algebra, are built (Ketterlin-Geller et al., 2008). In the long run, the lack of a strong foundation in mathematics leads students away from taking higher levels of mathematics and pursuing careers in mathematics-related fields (Mutlu, 2019).

Although enrollment in advanced mathematics coursework is associated with higher levels of college enrollment and subsequently, college and career success (Foegen, 2008; Larson, 2011), students struggle to demonstrate proficiency in more basic levels of mathematics. Data from standardized assessments shows that a majority of students are still not demonstrating proficiency. In 2019, 68% of eighth graders nationwide were ranked “At or above basic” on the National Assessment of Educational Progress, while only 33% were “At or above proficient” (National Assessment of Educational Progress, 2020). Additionally, only 39% of high school students in the class of 2019 reached college readiness benchmarks in mathematics (ACT, Inc., 2019). While there is an increased pressure on high schools to produce college-ready graduates, students as a whole, are seemingly not prepared for the rigors of college-level mathematics.

**Purpose**

The primary purpose of this study was to investigate the efficacy of two instructional intervention tools as methods to address deficiencies in foundational mathematics content knowledge for students struggling in mathematics at the high school level. The first intervention tool was conceptual mathematics games that were used as part of regular classroom instruction. This study investigated the effects of games on student achievement in mathematics by utilizing conceptual mathematics games, originally designed for upper elementary through high school, which focus on the development of basic mathematics skills.

This study also investigated another common intervention tool used to address struggling learners in the mathematics classroom, double dose programs. These programs increase instructional time within the school day to allow both level-appropriate instruction, as well as instruction focusing on prerequisite skills. While some double dose programs are used for enrichment or to allow students to achieve higher levels of mathematics, this study focused on a double dose program that targeted gaps in foundational content knowledge.

This study was grounded in the belief that the struggles students experience in the learning of grade-level mathematics is due largely to inadequately developed foundational and prerequisite mathematics skills from previous years. Thus, the focus of both intervention tools was on the development of prerequisite mathematics skills.

**Research Questions**

The following questions guided the research for this study:

1. For students who are struggling in mathematics, how does the use of games, the implementation of a double dose structure, or the combination of both affect growth on progress monitoring assessments?
2. For students who are not struggling in mathematics, to what extent does the use of games, the implementation of a double dose structure, or the combination of both affect performance on progress monitoring assessments?

## Literature Review

### Games

The use of games in an educational setting has the potential to aid in cognitive, emotional, and social development as students are more engaged with the content (compared to traditional methods), and are more motivated to learn (Ernest, 1986; Mostowfi et. al, 2016; Sardone & Devlin-Scherer, 2016). Beyond content knowledge and academic achievement, research has shown that using games as an instructional tool helps students develop problem solving skills and encourages cooperation, even when students are competing against one another (Ernest, 1986; Pope & Mangram, 2015). The use of games is ideal for low-performing students as it is often viewed as more interesting and provides more opportunities for students to receive positive feedback (Jimenez-Silva et al., 2010).

In a study to investigate the effect of games on students' performance (Ku et al., 2014), three characteristics of games were found to have a positive effect: specific goals, immediate feedback, and various levels of challenge. Sardone & Devlin-Scherer (2016) add that games create unique learning environments that challenge students to set goals, process information, apply knowledge, and make strategic decisions to achieve these goals. Having specific goals and providing immediate feedback are especially important for struggling students as they help these students understand what success looks like and what they need to do to achieve success. The various levels of challenge allow access to the mathematics for students of all abilities (Ku et al., 2014).

There are mixed results regarding the efficacy of games on student learning. Chang et al. (2018) conducted a research review of 22 studies that used games in the classroom. Of these studies, 13 had results that showed positive effects of games on student achievement, while the remaining nine studies showed no significant difference when games were used. A separate review (Ke, 2009) of 69 studies investigating the impact of games showed positive results in 34 studies, with 12 showing no significant difference.

### Double Dose Programs

One of the methods for assisting students who are struggling is to allow additional time for students to understand the concepts (Louie et al., 2008; Wadlington & Wadlington, 2008). Research has indicated that there is a strong relationship between the amount of instructional time and the level of student achievement which is even stronger when appropriate instructional strategies are implemented during the additional time (Louie et al., 2008). To provide additional structured time with the content, schools implement double dosing structures. These double dosing structures provide students with a second instructional period built into their schedule, allowing for double the amount of instructional time for the content (Cortes et al., 2013). Although the most common use of a double dose structure is for remediation, it can also be used for enrichment (the second period is above grade level) or for maintenance (two grade-level courses) (Henry et al., 2016). Double dosing structures for mathematics remediation commonly take the form of pull outs from a non-mathematics course to get supplemental mathematics instruction or enrollment in a second mathematics course (two different mathematics courses in the same year) (Henry et al., 2016). In the latter case, a student would typically have one period of on-level (grade-level) instruction and one period of remedial-level instruction (Tidd et al., 2018). In either scenario, additional instructional time should be spent with a qualified instructor who has a strong knowledge of the content and knows how to work with students who are struggling (Wadlington & Wadlington, 2008).

One drawback of using double dose structures is that students are homogeneously grouped. Struggling students are grouped with other struggling students who are significantly lower in their mathematics abilities which may have an impact on the overall growth that a student may experience (Cortes et al., 2013). In one study, there was no statistically significant impact on the achievement of struggling ninth grade students when the double dose intervention was implemented (Tidd et al., 2018). Additionally, results of a study of double dose programs in the Chicago Public Schools system in 2003 showed no improvement in the failure rate of ninth-grade students taking Algebra 1 (Cortes et al., 2013). However, the study of Chicago Public Schools showed that there were positive, long-term results in the form of increased scores on college entrance exams, higher high school graduation rates and increased college attendance rates (Cortes et al., 2013).

## Methodology

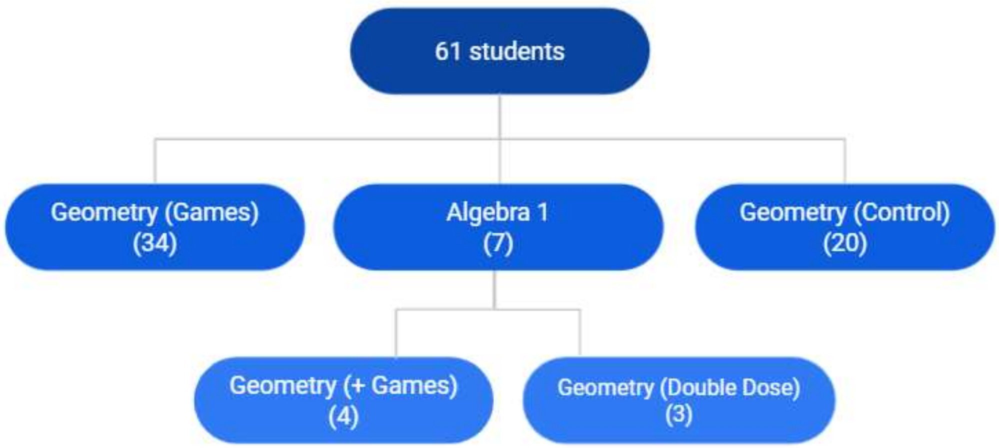
### Setting and Participants

This study took place in a Hawai'i private school which was conveniently and purposefully chosen for its preexisting double dosing structure, as its decision to implement the games as part of normal classroom instruction. The students were grouped into four groups based on the intervention(s) they received in their class. The first group, the *games* group, received one intervention tool, weekly game play, as part of classroom instruction. The games that the teacher implemented were conceptual mathematics games developed by the Curriculum Research & Development Group. Students in the second group, the *double dose* group, were enrolled in two periods of mathematics instruction. In the primary mathematics period, the students received grade level instruction. In the other period, which served as the supplementary mathematics period, instruction focused on the development of foundational skills. Some of the students who received two periods of mathematics also received game play in their primary mathematics course. These students were in the *both interventions* group. Finally, a *control* group received neither of the interventions. The inclusion of a control group helped to account for any growth seen due to the use of the assessments, any modifications to instructional practices, or simply due to the passing of time, and was used as an established baseline to which data from the other groups was compared.

A total of 61 ninth grade students were included in this study, all of whom were enrolled in one of the courses taught by the participating teacher. It can be assumed that the assignment of students to these periods were random, with the exception of students enrolled in the double dose period. For these students, the school determined criteria for placement into the double dose structure, mostly earning a failing grade in a previous math course. Of the 61 students, 34 were in the games group. Since the school had established specific criteria for inclusion into the double dose program, the Double Dose group, with only seven students, was the smallest group. Of the seven students enrolled in the double dose structure, four also received game play as part of classroom instruction in one of their mathematics classes. This means three students were in the Double Dose group, and four were in the group receiving both interventions. The remaining 20 students were in the control group. The assignment of students into the intervention groups is illustrated in Figure 1.

**Figure 1**

*Assignment of Participants into Intervention Groups*




The intervention tools were implemented by the classroom teacher as part of normal classroom instruction. This teacher was interested in evaluating the double dose program that was already being used for struggling students. Additionally, the teacher wanted to compare the effectiveness of this program to the use of games to support the needs of struggling students. It is reasonable for a teacher to modify instruction, implement instructional tools, and assess student learning as a part of normal instruction at his or her discretion. The researcher was only granted access to deidentified scores in an effort to assist the teacher in evaluating the efficacy of the changes they made to their instructional practice. Since deidentified data was gathered, students remained anonymous and there was no risk of violation to students' privacy. However, this meant that the researcher did not know and, thus, could not collect any additional demographic information on the students (e.g., gender, socioeconomic status, etc.). A future study could look at the demographics of students to determine if any factors correlate to any patterns observed in assessment scores.

**Data Collection**

Progress monitoring is the collection of student data, in regular and frequent intervals, used to determine a student's progress in an academic area (Foegen, 2008; Yell et al., 2008). Progress monitoring allows a teacher to determine what effect their instruction has on their students' progression toward mastering basic skills. A key facet of progress monitoring is that there are multiple forms of the assessment (Foegen, 2008; Yell et al., 2008). This allows a more accurate measure of student growth as the content and difficulty of the measures remain constant rather than the more common classroom assessments that change to reflect the topics being covered at a particular point in time.

The assessments that were used for this study are the Algebra Basic Skills measures developed under Project AAIMS at Iowa State University (2014). The AAIMS Algebra Basic Skills assessments are indicators of general proficiency in algebra (Foegen, 2008). Rather than assess students' proficiency in level-appropriate mathematics skills, the Algebra Basic Skills assessments cover mathematics skills taught prior to high school that have been determined as necessary for success in algebra, including evaluating expressions, solving simple equations, and combining like terms. This is consistent with this study's purpose of supporting the development of proficiency in more foundational mathematics skills.

In addition to multiple forms, progress monitoring assessments should be given frequently and at regular intervals (Foegen, 2008; Yell et al., 2008). For this study, one version of the assessment was given at the beginning of the study as a pre-assessment. To effectively monitor students' progress over the course of the study a different version of the assessment was given approximately once every two weeks. A total of six assessments were given over the course of the study with the first serving as the pre-assessment and the sixth serving as the post-assessment.

To determine the effects of the intervention tools, this study collected deidentified student scores on the progress monitoring assessments from 61 ninth grade students. In order to maintain student privacy, all identifiable student information was removed prior to the scores being provided to the researcher. The teacher assigned each student a code number that the students used to identify themselves on their assessments. Only the teacher was able to access the key that linked students to their code numbers, which was kept in a secure location throughout the course of the study. The only information that was available was the instructional intervention group to which the student was assigned.

**Data Analysis**

This study looked at the impact of the two intervention tools on the assessment scores of students identified as struggling, as well as those who are not considered struggling. A student's score was compared to the scores of the other students in the sample (local norms), to determine cut off scores. The use of local norms is more accurate as it allows for the consideration of characteristics of the sample population (Sandberg Patton et al., 2014). To determine which students are considered struggling, the scores from the initial assessment were used. Standardized scores were calculated and students scoring more than one standard deviation below the mean were considered struggling.

***Missing Data.*** Missing data is common in studies that take place in the school setting due to sickness, truancy, and dropouts. One of the more common methods for addressing missing data is to exclude any subjects with missing data points (Cokluk & Kayri, 2011; Genolini et al., 2013). However, for small samples and those with many subjects with missing data, excluding subjects is not ideal or statistically advantageous as it might unknowingly introduce bias due to a difference in those who have and those who do not have missing values.

Rather, this study used imputation, the process of inputting a value for any that are missing. Under this method, a researcher can input values for any missing data points (Cokluck & Kayri, 2011; Genolini et al., 2013). This study implemented the linear interpolation method for inputting missing data. Linear interpolation uses the two closest non-missing values on either side of the missing value to create a line (Genolini et al., 2013). In linear interpolation, there is the assumption that whatever trend was seen between two points remained constant for every missing data point in between.

A student missing a score for either the pre-assessment or the post-assessment would be excluded as linear interpolation would be impossible. Additionally, the absence of these critical data points does not allow for proper classification of struggling or non-struggling (in the case of a first assessment missing) or to see final achievement level (for subjects missing the final/post assessment). Furthermore, any subject missing more than two data points was excluded from data analysis. Missing three or more data points would mean that, at most, only half of the data points were actual data, not imputed values.

## Results and Discussion

The pre-assessment scores (*n* = 61) had a mean of 17.2 points with a standard deviation of 6.9. A histogram and normal probability plot of the pre-assessment scores showed approximate normality and indicated no serious violations to normality. Basic statistical analysis identified no outliers. While the overall sample of 61 students is small, the normality of pre-assessment scores ensures that the sample included students at all levels and does not include exceptionally high-scoring or low-scoring students. This also allowed the use of standardized *z*-scores to help identify the students that would be classified as struggling for the purpose of this study. Any student scoring more than one standard deviation below the mean score was considered struggling. Table 1 shows the breakdown of students by instructional intervention group and struggling classification.

**Table 1**

*Breakdown of Students by Intervention Group and Struggling Classification*

| Instructional Intervention Group | Classification | |
|---|---|---|
| | Struggling | Non-Struggling |
| Games | 3 | 31 |
| Double Dose | 1 | 2 |
| Both Interventions | 2 | 2 |
| Control | 2 | 18 |
| Total | 8 | 53 |

### Intervention Tools for Struggling Students

There were eight students who were classified as struggling. Of the eight students, three were in the Games group, one was in the Double Dose group, two were enrolled in the Both Interventions group, and two were in the Control group. Table 2 shows the scores for each of the struggling students on each of the six assessments.

**Table 2**

*Assessment Scores for Struggling Students*

| | Assessment Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Student | Pre | 2 | 3 | 4 | 5 | 6 | Net Change | Instructional Intervention Group |
| A | 9 | 12 | 11 | 10 | 13 | 10 | +1 | Games |
| B | 9 | 21 | 15 | 15 | 17 | 16 | +7 | Games |
| C | 6 | 5 | 11 | 12 | 3 | 5 | -1 | Both Interventions |
| D | 3 | 5 | 4 | 5 | 7 | 15 | +12 | Both Interventions |
| E | 5 | 3 | 6 | 6 | 7 | 4 | -1 | Double Dose |
| F | 8 | 16 | 19 | 21 | 23 | 25 | +17 | Games |
| G | 8 | 17 | 11 | 15 | 15 | 11 | +3 | Control |
| H | 6 | 5 | 9 | 5 | 9 | 5 | -1 | Control |

*Note*: Net Change values were calculated by: Assessment 6 score – Pre-assessment score

Of the eight struggling students, five showed a positive net change (net gain) in assessment score between the pre-assessment and the final assessment (Assessment 6) while the remaining three students showed a negative net change (net loss). The average net change for all struggling students was 4.6 points. When grouped by instructional intervention groups, three of the groups (Games, Control, and Both Interventions) had a positive net change in the mean group scores (Assessment 6 - pre-assessment) indicating growth over the course of the study (Table 3). The students in the Games group showed the largest change, increasing their mean score by 8.3 points. The Both Interventions group and Control group also had a positive net change (5.5 points and 1 point, respectively). The Double Dose group was the only instructional intervention group that showed a negative net change in mean score.

**Table 3**

*Group Means for Struggling Students*

| | Assessment Number | | | | | | |
|---|---|---|---|---|---|---|---|
| Instructional Intervention Group | Pre | 2 | 3 | 4 | 5 | 6 | Net Change[a] |
| Games | 8.7 | 16.5 | 15.0 | 15.3 | 17.7 | 17.0 | 8.3 |
| Double Dose | 5.0 | 3.0 | 6.0 | 6.0 | 7.0 | 4.0 | -1.0 |
| Both Interventions | 4.5 | 5.0 | 7.5 | 8.5 | 5.0 | 10.0 | 5.5 |
| Control | 7.0 | 11.0 | 10.0 | 10.0 | 12.0 | 8.0 | 1.0 |

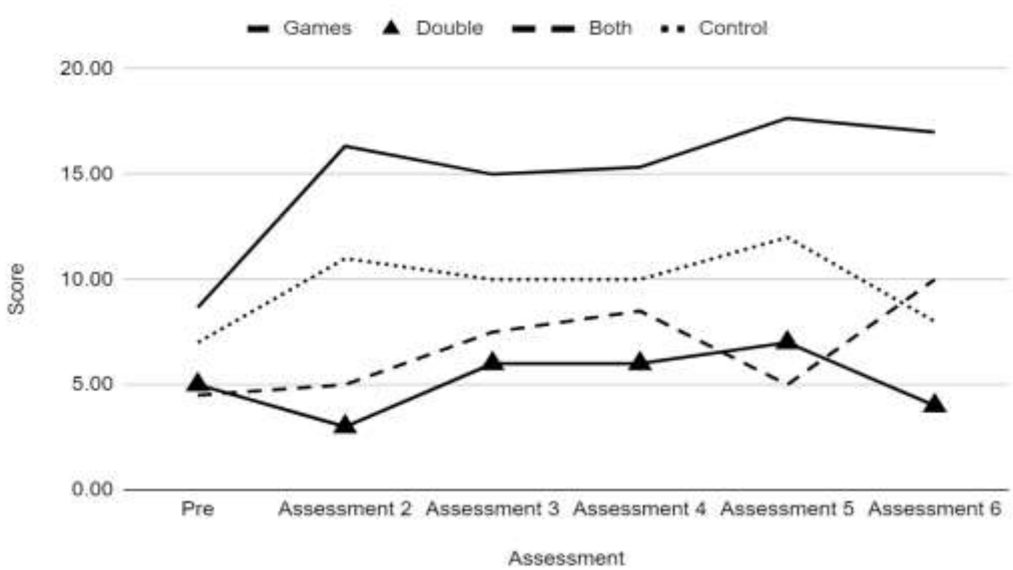
*Note:* Net change values are calculated by: Assessment 6 score – Pre-assessment score

A one-way ANOVA test indicates that there was no significant difference [$F(2,4) = .57$, $p = .60$] between the groups that received games, those that received both, and the those that received no intervention. Since there was only one struggling student who was in the Double Dose group, this group was excluded from the ANOVA test. Although this may suggest that the intervention tools implemented had no significant impact on the assessment scores, the extremely small sample sizes raises concerns over the validity of any statistical analyses.

Figure 2 shows the mean group scores for the struggling students across the data collection period. The graph highlights two important points. First, it shows that the students in the Double Dose and Both Intervention groups were consistently the two lowest scoring groups. This makes sense considering that the students in these two groups, whether struggling or not, were enrolled in the double dose structure due to some sort of deficiency in their mathematics skills. It also provides further evidence that the students who received the double period of mathematics were weaker in foundational mathematics skills.

**Figure 2**

*Graph of Assessment Scores for Struggling Students by Group*




Second, the graph shows how the variation between the groups increased over the course of the study. At the beginning of the study, the mean scores for the groups showed very low variability, with approximately a 5-point difference between the highest and lowest scoring groups. At the end of the study, however, mean scores on the final assessment showed much more variation, with a 13-point difference between the highest and lowest groups. The data from this study suggests that for struggling students, the groups did not improve at the same rate, with the games group showing growth at a faster rate than the other groups.

Trend lines using the mean scores on each assessment were calculated for each of the groups. The struggling students in the games group showed the greatest average growth (M = 8.3) and had a trend line with the largest slope ($m$ = 1.31). The students who received both instructional interventions showed the next highest average growth rate (M = 5.5, $m$ = 0.81). A common factor among both of these (Games and Both Interventions) is that they both received game play. This suggests that the use of mathematics games can be beneficial to facilitate growth in mathematics performance for struggling learners.

On the other hand, the Control and Double Dose groups showed very little change, overall. The Control group showed an average increase of 1 point over the course of the study with a trend line slope of 0.23. The Double Dose group had an average decrease of 1 point and the lowest trend line slope of all four groups ($m$ = 0.20). While the double dose structure increased instructional time, it is possible that the double dose simply provided more of the same instruction (e.g., same quality of instruction, same pedagogical strategies, etc.). This would suggest that increasing instructional time alone might not be enough to facilitate growth for struggling students. Similarly, for the students in the control group, it is assumed there is no change to instruction, which suggests that without any intervention, struggling students will not progress in their mathematics abilities.

**Effects of the Intervention Tools for Non-Struggling Learners**

Although the primary focus of this study was to investigate the impacts of instructional intervention tools to support struggling learners, consideration was also given to the effects that these tools had on non-struggling learners. The remaining 53 students who were not identified as struggling were considered non-struggling. Of these students, 31 (58.5%) were in the Games group, two (3.8%) were in the Double Dose group, two (3.8%) were in the Both Interventions group, and 18 (34.0%) were in the Control group. Table 4 shows the mean score on each assessment for non-struggling students broken down by the instructional intervention group.

Of the 53 non-struggling students, 37 (69.8%) had a positive growth score (Assessment 6 score was greater than the pre-assessment score), 13 (24.5%) scored lower on the Assessment 6 than they did on the pre-assessment, and the remaining three (5.7%) had the same score for both assessments. For all non-struggling students, a $t$ test for the mean difference (Assessment 6 score – Pre-assessment score) > 0 showed a statistically significant result, $t(52) = 4.14$, $p < .001$. This indicates an improvement in the mean score over the course of the study. Two groups, Games and Control, showed an increase in mean score (positive net change). The Double Dose and Both Interventions groups showed a decline in mean score and had the lowest mean score on every assessment (Figure 3). This trend was also observed for the struggling learners in the same two groups. More importantly, this resulted in a widened gap in mean scores at the end of the study.

**Table 4**

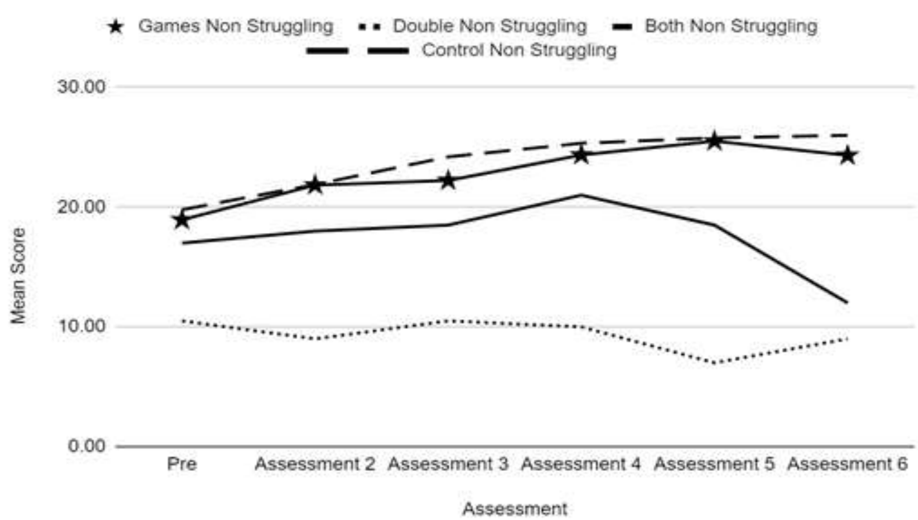
*Summary Data for Non-Struggling Students by Group*

| | Assessment Number | | | | | | |
|---|---|---|---|---|---|---|---|
| Instructional Intervention Group | Pre | 2 | 3 | 4 | 5 | 6 | Net Change |
| Games | 18.9 | 21.8 | 22.2 | 24.3 | 25.5 | 24.3 | 5.4 |
| Double Dose | 10.5 | 9.0 | 10.5 | 10.0 | 7.0 | 9.0 | -1.5 |
| Both Interventions | 17.0 | 18.0 | 18.5 | 21.0 | 18.5 | 12.0 | -5 |
| Control | 19.8 | 21.9 | 24.2 | 25.3 | 25.8 | 26.0 | 6.2 |
| All Non-struggling | 18.8 | 21.2 | 22.3 | 24.0 | 24.6 | 23.9 | 5.0 |

*Note:* Net change values are calculated by: Assessment 6 score – Pre-assessment score

**Figure 3**

*Graph of Assessment Scores for Non-Struggling Students by Group*




Although this might suggest that the use of the double dose structure is not beneficial for non-struggling students, it should be noted that the double dose structure, at least for the purpose of this study, was meant as an intervention for students who were already identified as having some sort of deficiency in their mathematics knowledge (i.e., struggling). Thus, it might make sense that students in the Double Dose and Both Interventions groups will perform at a lower level than the students in the Games and Control groups. Knowing this, it might be better to consider all students receiving the double dose intervention as struggling.

The students in the control group showed consistent growth over the study period with an increase in the mean score of 6.2 points. According to a *t*-test for the mean difference > 0, this was a significant increase, $t(17) = 3.00$, $p = .004$. The control group had the highest mean score on every assessment. This would suggest that non-struggling students can show growth without the use of any of the interventions that were used in this study.

Over the course of the study, the Games group showed an average increase of 5.4 points in the mean score. A *t*-test for the mean difference in test scores > 0 indicated a statistically significant difference, $t(30)= 3.57$, $p < .001$. This suggests that the use of games could still be beneficial to students who are not considered struggling. While both the Control and Games groups showed significant improvement, a two-sample *t* test for a difference between two means (Games – Control > 0) indicated that the difference between the two groups was not statistically significant [$t(35) = -0.32$, $p = .625$].

Table 5 shows the percent change ([final value – initial value] / initial value) between subsequent assessments. The average percent change for the Control group was higher than that of the Games group which might suggest that the use of games may not have had any added benefit for the non-struggling students. However, the percent change for the control group, while always positive, was decreasing over the course of the study, slowing to almost no change between the fifth and final assessments. This slowing of growth might indicate that students in the control group have plateaued in their learning. It is unclear if this trend would hold true for future assessments, with percent changes possibly reaching zero or becoming negative.

**Table 5**

*Percent Change Between Subsequent Assessments*

| | Assessment Intervals | | | | | |
|---|---|---|---|---|---|---|
| Instructional Intervention Group | Pre to 2 | 2 to 3 | 3 to 4 | 4 to 5 | 5 to 6 | Average |
| Games | 15.3% | 1.8% | 9.6% | 4.8% | -4.7% | 5.4% |
| Control | 10.7% | 10.5% | 4.7% | 1.8% | 0.9% | 5.7% |

*Note:* Percent change is calculated using the formula (final value - initial value) / initial value.

**Summary of Findings**

For struggling learners, the scores for the Games group showed the largest growth, indicating that the use of games was the most effective instructional intervention tool for these students. The use of games may not have been as beneficial for the non-struggling students, but it did not have any observed adverse effects. The data from this study suggests that games might be useful for maintaining mathematics skills and may show more promise longitudinally.

The double dose structure did not show as much promise as the use of games. While this increased instructional time for struggling students, it is not clear if the additional instructional time implemented any research-based instructional strategies for teaching struggling students. The additional instructional time provided by the double dose program was not intended as an intervention for non-struggling students and was equally ineffective at increasing assessment scores.

Without the use of either of the interventions, non-struggling students showed growth in assessment scores over the course of the study, but it is unclear if this growth can be sustained over a longer period of time. However, struggling students did not benefit from status quo instruction, providing further support for the need for interventions to help address the needs of these students.

## Limitations

The primary criterion for selecting a school was having an established double dose structure. Because of this, the school would not necessarily be representative of the population. It is not clear how the teacher and student demographics or other factors of the school (e.g., curriculum used, instructional minutes, etc.) compared to other schools. Since this study took place in a private school, other factors may make this school even less representative of the population, such as the socioeconomic status of students (e.g., the resources available to the students, especially when instruction went virtual), value placed on education, or increased motivation or pressure from external (or even internal) sources to perform well. Future studies might consider a site that is more representative of a larger population (e.g., a public school).

The sample size was one of the major limitations of the study. With a total sample size of 61 students, and with some subgroups having less than five students, basic statistical analysis (e.g., comparing means or measures of variation) would have had little validity. The disparity between the subgroup sample sizes would also raise concerns (e.g., one subgroup had 31 students and another had only two). Although the small sample sizes were problematic, they were partially a result of maintaining other aspects of the study that helped to strengthen the research design. This allowed consistency in instruction and minimized the potential effects of having different schools or teachers (i.e., differences in school and teacher demographics and pedagogical strategies). Future studies could focus on having larger sample sizes by allowing multiple schools or teachers. While this might potentially introduce other limitations, the larger sample sizes would allow the use of statistical analyses.

Although results indicate that games could be a promising instructional intervention tool for helping struggling learners, the small sample size does put into question the extent to which these results are applicable to a larger population. This provides justification for future studies where other factors that could potentially affect student performance (e.g., online versus face-to-face instruction, attendance rates, class size, etc.) could be observed to identify any that might contribute to the success of the games.

Finally, the classification of students was based on a single assessment score. Scores could have been affected due to unfamiliarity with the assessment items or the online format of the assessment. It is not clear if the scores on this assessment were representative of the students' actual mathematics ability. This could also lead to students being incorrectly classified as struggling.

## Future Research

Future research could gather data on more factors such as the number of times a student is absent from class, scores on other (e.g., course-related) assessments, or the curriculum being implemented. A study might investigate the structure of the supplementary course of double dose programs, including the types of activities implemented, the ratio of supplemental instruction to regular instruction, or the curriculum that is used. For the games group, future studies might consider the frequency of game use and students' progress on games scores (i.e., do students improve at the games over the course of the study and does that translate to better assessment scores?). Inclusion of the student voice in the data analysis could help to understand the instructional intervention tools and might provide insight into any trends that may manifest in the assessment scores.

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