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# Scaffolding Students' Difficulties in Addition and Subtraction of Integers through Game-Based Instruction

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**Abstract.** This study aimed to determine the effectiveness of the Integer Math Maze and Intego Card Game in teaching and learning the addition and subtraction of integers. The study also covered the level of the students' enjoyment of utilizing these game-based instructions. The subjects of the study were the 41 Grade 10 students who were grouped into two based on their prior knowledge of mathematics and were randomly assigned to different interventions. The study utilized the Cluster Randomized Trial (CRT) under the experimental type of research. Mean, Spearman Rank Order Correlation, and a t-test for independent and dependent data were used as statistical tools. The researchers used a validated questionnaire to gather data. The findings of the study indicate that the students lack the foundational skills in integer operations. However, a significant improvement in their performance was observed after the utilization of the game-based instructions. The study further revealed that the level of the students' enjoyment of the game-based instructions was "very high." The data from this study indicated that, to scaffold students' difficulties with the various operations of integers, educators and curriculum implementers should examine how well students perform when given game-based instruction.

**Keywords:** Scaffolding student' difficulties; Game-based instruction; Addition and subtraction; Integer math maze; Intego card game.

## 1.0 Introduction

Everyday living requires the ability to use numbers (Davis-Kean et al. 2022; Szabo et al., 2020). Literacy in mathematics entails comprehending and synthesizing mathematical fundamentals, such as concepts, terminology, facts, and skills, following the demands of real-world situations (Tallud & Caballes, 2023). However, studies have shown that students struggle with math globally, making it crucial to find solutions to these problems and close learners' numeracy gaps (Morrison & McLafferty, 2018). According to Camera (2019), U.S. students are somewhat below average in mathematics when seen from a worldwide viewpoint. Many nations around the world are quite concerned about low math achievement. Fiji is one of the South Pacific countries experiencing the same trends, pressures, and worries, as stated by Chand et al. (2021). Kosovar pupils also do worse than average in science and math (Shala & Grajcevci, 2023).

Based on the 2018 international assessment, the performance of Filipino students in Mathematics continuously showed a decline. They scored 297 in math and this figure is substantially lower than that of any other country that joined the TIMSS (Magsambol, 2020). Only 19% of Filipino students met the "low standard" in math, indicating they had "some basic mathematical knowledge," while 81% did not even make it to this level. In addition, the study by Bulangis (2021) revealed that students' Basic Education Exit Assessment (BEEA) performance particularly in problem solving is at the "low proficient" level. The purpose of BEEA performance is

to evaluate students' academic growth and gauge whether or not the students have mastered the set of learning requirements.

Researchers discovered that the COVID-19 pandemic impeded learners' academic growth (Omang & Angioha, 2021; Isiaka, 2021). Thus, mathematics researchers identified the challenges encountered by the students during the pandemic (Meniano & Tan, 2022; Fernandez & Benavides, 2022; Bayucca, 2021). Other researchers also tried to explore the difficulties of the teachers in teaching the subject after the pandemic (dela Cruz & Hernandez, 2023; Fickermann & Edelstein, 2020; Villarreal et al., 2022; Atweh et al., 2022). Nonetheless, the current research intends to scaffold students' difficulties in the addition and subtraction of integers. These topics in mathematics are very useful in higher and advanced mathematics learning. As Sahat et al. (2018) stressed, integers are topics that are crucial to understanding other higher mathematical ideas. Due to their close connection to daily life, integer operations are an extremely essential subject.

The researchers, being mathematics teachers were challenged to find effective ways to teach addition and subtraction of integers given the subject's perceived difficulty. So, they decided to use game-based instruction to motivate the learners to comprehend the concepts of integers. Hakim et al. (2019) contend that using tangible objects enables students to learn through practical application, which might be more engaging and readily remembered than learning through purely abstract notions. Chong et al. (2022) also indicated that using games in teaching can be a helpful tool in imparting concepts. This prompted the researchers to use game-based instructions to scaffold students' difficulty in adding and subtracting integers. With this in mind, the researchers also would like to identify the level of students' enjoyment and if it relates to their performance.

Generally, this study determined the effectiveness of game-based instruction in teaching and learning addition and subtraction of integers. Specifically, it (a) assessed the pretest and posttest results of the students in adding and subtracting integers; (b) identified difficulties of students in adding and subtracting integers; (c) examined students' level of enjoyment of the game-based instruction in scaffolding their difficulties in adding and subtracting integers; (d) explored the difference between the pretest and posttest results of the students in addition and subtraction of integers; (e) evaluated the difference in the posttest results of the two groups of students in addition and subtraction of integers; and (f) examined the relationship between the level of students' enjoyment of the game-based instruction and their posttest performance. Its findings will be helpful not just to math teachers but also to any educational institution that wants to improve students' numeracy skills, especially when it comes to addition and subtraction of integers.

## 2.0 Methodology

### 2.1 Research Design

This study utilized the Cluster Randomized Trial (CRT) under the experimental type of research. In CRT, participants are not individually randomized to different groups. Instead, clusters of participants (two sections of students) are randomly assigned to different interventions—the Integer Math Maze and Intego Card Game. The researchers ensured that the two groupings of students had the same level of prior knowledge in Mathematics 9.

### 2.2 Research Participants

The respondents of this study were the Grade 10 students of Leon Parami High School (LPHS), Po-o, Lazi, Siquijor, enrolled during the school year 2023-2024. The researchers employed the one-stage cluster sampling method in choosing the respondents. The assignment of activity was done at random by tossing a coin. To ensure that the two groupings have equal knowledge of Mathematics, their prior performance in Mathematics 9 was identified. The t-test for independent data was then employed and the results showed a p-value greater than 0.05. This validated the assumption that the knowledge of the two groupings is the same.

### 2.3 Research Instrument

The entire questionnaire was presented to three experts in the field of mathematics for content validity. The experts were properly selected by the researchers. To ensure item reliability, a dry run was conducted with 30 selected students as the respondents. These students participating in the dry run were also the participants in the trial of the game-based instruction for them to thoroughly evaluate their level of enjoyment. The Cronbach's Alpha

Test was utilized and revealed an item reliability of 0.870 and 0.810 for the Integer Math Maze and Intego Card Game, respectively.

### 2.4 Data Gathering Procedure

Before the administration of the questionnaires, both for the initial experiment/dry run and the final experiment, the researchers asked permission from the Schools Division Superintendent of Siquijor. The signed and approved request was presented to the school principal of Leon Parami High for formal permission the conduct the study. Before conducting the experiment, the researchers conducted first a trial experiment in another section. The game was introduced first to every group and was tested afterward. The questionnaire on students' enjoyment of the game-based instruction was also distributed to identify the reliability of the items. After the initial experiment, the researchers evaluated their strengths and weaknesses during the conduct of the activity. The students' behavior was also considered. The Grade 10 students are composed of two sections with 20 students in Grade 10 Aguinaldo and 21 students in Grade 10 Bonifacio. After having proof that these two sections of students have equal knowledge in mathematics, the assignment of activity was done in random through the tossing of a coin. The students were then briefed on what to expect during the conduct of the activity. For the final experiment, each group was given a pre-test to be answered for 20 minutes. Afterward, they were made to play two different games (Integer Math Maze and Intego Card Game). The concepts introduced through games served as enrichment activities in adding and subtracting integers. After each game, the students answered the post-test for 20 minutes. This determines if the activities are effective in the teaching-learning process.

### 2.5 Ethical Considerations

The researchers observed all the necessary ethical considerations during the entire duration of the study. Since the data involved the performance of the students, confidentiality of information was assured to those concerned such that their privacy would not be encroached upon. The researchers also followed the ethical protocols stipulated in the Ethics Committee of Foundation University. Before the conduct of the study, permission was sought from the proper authorities.

## 3.0 Results and Discussion

### 3.1 Pretest Results of the Students in Adding and Subtracting of Integers

Table 1 displays the pretest results of the two groups of students in adding and subtracting integers. The data show that the students' mean performances fall within the "did not meet expectations" category with ratings of 73.33% for the Integer Math Maze Group and 74.13% for the Intego Card Game Group. These ratings imply that the students struggle with their understanding of the concepts or rules of adding and subtracting integers.

**Table 1.** Pretest results of the students in adding and subtracting of integers

| RATING | INTEGER MATH MAZE GROUP (N = 21) | | INTEGO CARD GAME GROUP (N = 20) | |
|---|---|---|---|---|
| | F | % | F | % |
| 90% - 100% | 0 | 0.00 | 0 | 0.00 |
| 85% - 89% | 1 | 4.76 | 1 | 5.00 |
| 80% - 84% | 3 | 14.29 | 5 | 25.00 |
| 75% - 79% | 5 | 23.81 | 5 | 25.00 |
| ≤ 74% | 12 | 57.14 | 9 | 45.00 |
| **Mean** | **73.33 (Did Not Meet Expectations)** | | **74.13 (Did Not Meet Expectations)** | |
| **SD** | **5.55** | | **6.25** | |

Addition and subtraction of integers were discussed in Grade 6 and the students in Grade 10 were unable to fully comprehend the rules resulting in a failing performance. These students might have been affected by the implementation of modular distance learning. The shift to modular distance learning started in the year 2020 and these groups of students were in Grade 7. Teachers in the study of Muthuprasad et al. (2021) claimed that the pandemic caused students to struggle with concretizing some mathematical concepts. This was also affirmed in the study of Fernandez and Benavides (2022) that the students' numeracy skills have declined since the implementation of modular distance learning.

### 3.2 Difficulties of Students in Adding and Subtracting Integers (n=41)

Table 2 reflects the items that students found difficult in adding and subtracting integers. Based on the result of their pretest, it was found that the students had difficulty in subtracting and adding integers. To verify the results concerning the students' incorrect responses, the researchers interviewed with randomly selected students.

**Table 2.** Difficulties of students in adding and subtracting integers (n = 41)

| RULES | PROBLEM | FREQUENCY OF STUDENTS WITH CORRECT RESPONSES | % |
|---|---|---|---|
| **Subtraction** | | | |
| 1. Form of the Integers: (+) – (-)<br>Rule: change the sign of the subtrahend; change the operation to addition; and proceed to the rules of adding integers. | (+4) - (-9) | 2 | 4.88 |
| 2. Form of the Integers: (-) – (+)<br>Rule: change the sign of the subtrahend; change the operation to addition; and proceed to the rules of adding integers. | (-6) - (+9) | 2 | 4.88 |
| 3. Form of the Integers: (-) – (-)<br>Rule: change the sign of the subtrahend; change the operation to addition; and proceed to the rules of adding integers. | (-9) - (-4) | 12 | 29.27 |
| 4. Form of the Integers: (+) – (+)<br>Rule: change the sign of the subtrahend; change the operation to addition; and proceed to the rules of adding integers. | (+1) - (+5) | 13 | 31.71 |
| **Addition** | | | |
| 1. Form of the Integers: (-) + (-)<br>Rule: add the numbers then copy the common sign. | (-9) + (-4) | 8 | 19.51 |
| 2. Form of the Integers: (-) + (+)<br>Rule: get the difference and copy the sign of the greater number. | (-2) + (+8) | 14 | 34.15 |

In terms of subtracting a positive integer from another negative integer, only 4.88% of the students got the correct answer. Meanwhile, in subtracting a negative integer from another positive integer, only 4.88% of them got it right. Most students solve (+4) - (-9) = -5 and (-6) - (+9) = 3 because they fail to recognize that the negative sign after 4 and (-6) is operational, while the one attached to (-9) and (9) makes it an integer. In an interview, students said that instead of adding the numbers, they subtracted them and then copied the sign of the bigger number and this made their answers incorrect. On the other hand, in subtracting a negative integer from another negative integer, there are 29.27% of students correctly answered the item. Still, this percentage is low. They opened up that it is difficult for them to deal with negative numbers, especially in operation that involves subtraction. They further added that since the subtrahend and minuend have a common sign of negative, they would simply add the integers.

Concerning subtracting a positive integer from another positive integer, 31.71% of students got a correct answer. According to them, they found it hard to answer because they were dealing with different signs—the positive and negative integers. In this rule, the students should change the sign of the subtrahend, change the operation to addition, and proceed to the rules of addition. The students followed the rule but got confused when proceeding to the rule of addition. On the other hand, in adding two negative integers, only 19.51% of them got the correct answer. Some students got the correct operation to be used, but they forgot to copy the common sign.

Moreover, in adding a negative and a positive integer, 34.15% were can get the correct answer. In this rule, the students were confused because of the different signs. It was also found out that some of them correctly followed the rule by subtracting the numbers but they failed to copy the sign of the bigger number. Those students who subtracted the numbers but forgot to copy the sign of the bigger number were then asked why they did it the wrong way. They explained that they have difficulty identifying the bigger value because for them all negative numbers have smaller values than positive numbers.

The above findings expose the difficulty of the students in applying the different rules in integer operations due to their misconceptions and low foundation on how the different rules are applied. It was emphasized by Isa (2022) that number-related concepts are the main source of mathematical misconceptions. Furthermore, Khalid and Embong (2019) pointed out that the two potential causes for this misconception are the lack of knowledge of integer rules and the negative sign was misinterpreted. Khalid et al. (2019) have divulged that students scored lowest in the subtraction of integers.

### 3.3 Posttest Results of the Students in Adding and Subtracting of Integers

Table 3 reveals the posttest results of the students after the utilization of the following game-based instructions: Integer Math Maze and Intego Card Game.

**Table 3.** Posttest results of the students in adding and subtracting of integers

| RATING | INTEGER MATH MAZE GROUP (N = 21) | | INTEGO CARD GAME GROUP (N = 20) | |
|---|---|---|---|---|
| | F | % | F | % |
| 90% - 100% | 12 | 57.14 | 11 | 55.00 |
| 85% - 89% | 3 | 14.29 | 4 | 20.00 |
| 80% - 84% | 4 | 19.05 | 2 | 10.00 |
| 75% - 79% | 0 | 0.00 | 1 | 5.00 |
| ≤ 74% | 2 | 9.52 | 1 | 5.00 |
| **Mean** | **87.02 (Very Satisfactory)** | | **88.88 (Very Satisfactory)** | |
| **SD** | **7.48** | | **8.30** | |

The data reflect that the group of students who utilized the Integer Math Maze has a mean rating of 87.02% and those groups who used the Intego Card Game have a mean rating of 88.88%. These ratings are both in the "very satisfactory" classification. This means that the students have developed the fundamental knowledge and skills in adding and subtracting integers. These ratings are both in the "very satisfactory" classification. This means that the students have developed the fundamental knowledge and skills in adding and subtracting integers. With this, the students can transfer knowledge and perform the task independently. The study of Jasni et al., (2019) revealed that students can be indirectly exposed to the idea that learning can occur more engagingly and effectively with the teacher's guidance in the classroom.

The current results run parallel with that of Adedigba (2023) who emphasized that implementing game-based instructions in the classroom can greatly enhance numeracy skills. Rebollo et al. (2022) likewise found that students who study mathematics utilizing a game-based approach are more likely to comprehend the content presented in class and as a result, perform better academically.

### 3.4 Level of Students' Enjoyment of the Game-Based Instruction in Scaffolding Their Difficulties in Adding and Subtracting Integers

**Table 4.** Level of students' enjoyment of the game-based instruction in scaffolding their difficulties in adding and subtracting integers

| I ENJOY THE GAME-BASED INSTRUCTION BECAUSE… | INTEGER MATH MAZE GROUP (N = 21) | | | INTEGO CARD GAME GROUP (N = 20) | | |
|---|---|---|---|---|---|---|
| | **wx̄** | **VD** | **LoE** | **wx̄** | **VD** | **LoE** |
| 1. The goals of the game were presented at the beginning of the game. | 4.90 | SA | VH | 4.70 | SA | VH |
| 2. It helps me understand more concepts in adding and subtracting integers. | 4.90 | SA | VH | 4.75 | SA | VH |
| 3. It improves my knowledge of adding and subtracting integers. | 4.90 | SA | VH | 4.90 | SA | VH |
| 4. It is interesting. | 4.86 | SA | VH | 4.75 | SA | VH |
| 5. It is enjoyable. | 4.81 | SA | VH | 4.85 | SA | VH |
| 6. It engages me with the lesson. | 4.81 | SA | VH | 4.70 | SA | VH |
| 7. It generally makes learning math concepts in adding and subtracting integers fun. | 4.81 | SA | VH | 4.85 | SA | VH |
| 8. It encourages me to improve my skills in adding and subtracting integers. | 4.76 | SA | VH | 4.95 | SA | VH |
| 9. It motivates me to apply the knowledge taught in adding and subtracting integers. | 4.71 | SA | VH | 4.75 | SA | VH |
| 10. Its challenges are adequate - neither too difficult nor too easy. | 4.62 | SA | VH | 4.75 | SA | VH |
| 11. It excites me to join the class every day. | 4.62 | SA | VH | 4.80 | SA | VH |
| 12. It makes me temporarily forget my worries about everyday life. | 4.48 | SA | VH | 4.65 | SA | VH |
| 13. It eliminates boredom and anxiety. | 4.38 | SA | VH | 4.45 | SA | VH |
| **Composite** | **4.74** | **SA** | **VH** | **4.76** | **SA** | **VH** |

Table 4 displays the data identifying the level of students' enjoyment of the game-based instruction in scaffolding their difficulties in adding and subtracting integers. The data reflect that the composite means are 4.74 and 4.76 for the Integer Math Maze group and the Intego Card Game group, respectively. These figures indicate that the level of enjoyment of the two groups of students is "very high."

Specifically, the data expose that all indicators have ratings between 4.21 – 5.00, which signify a "very high" level of enjoyment. The students divulged that the goals of the games were presented before they started ($w\bar{x}$ = 4.90 and 4.70). They also claimed that the games helped them to understand more concepts in adding and subtracting integers ($w\bar{x}$ = 4.90 and 4.75) and their knowledge improved ($w\bar{x}$ = 4.90 and 4.90).

The above findings are enough to point out that students find game-based learning enjoyable since it facilitates greater interaction between them and their teachers. Game-based instruction is a student-centered method that requires the student's active participation throughout the lesson. This instruction allows the students to experience playing while learning, which is more enjoyable than traditional learning methods that cause the students to become bored (Rebollo et al., 2022). The study of Yang and Chen (2021) supported the current findings that game-based learning is an excellent method for teaching and mastering numeracy skills. Games are engaging and can make learning fun and interactive, which can increase motivation and retention.

**3.5 Difference Between the Pretest and Posttest Results of the Students in Addition and Subtraction of Integers**
Table 5 exposes the data showing the difference between the pretest and posttest results of the students in addition and subtraction of integers.

**Table 5**. Difference between the pretest and posttest results of the students in addition and subtraction of integers

| GROUP | N | PRETEST | POSTTEST | D | T-VALUE | P-VALUE | REMARK |
|---|---|---|---|---|---|---|---|
| Integer Math Maze | 21 | 73.33 | 87.02 | 13.69 | 7.458 | <.001 | Significant |
| Intego Card Game | 20 | 74.13 | 88.88 | 14.75 | 7.458 | <.001 | Significant |

Level of significance = 0.05

Using the Integer Math Maze game, a numerical difference in the students' pretest (73.33%) and posttest (87.02%) results is apparent. To statistically test the difference, a t-test for dependent data was applied, showing that the p-value (<.001) is less than the level of significance (0.05). This means that there is a significant difference between the student's pretest and posttest results. In other words, the utilization of the Integer Math Maze enables the students to comprehend the concepts of addition and subtraction of integers.

Furthermore, the game-based instruction improves their performance from "did not meet expectation" to the "very satisfactory" category. This result clarifies the issue that games are just merely recreational and time-wasting activities. The study found that game-based learning does improve students' numeracy abilities. The results of Siong and Osman (2018) also support the idea that game-based learning positively impacts students' academic performance. Andika et al. (2019) also confirmed that early numeracy skills development in young children may be supported by playing board games with a mathematical self-concept and that this considerably enhances the learners' mathematical self-concept and early numeracy abilities. Ompok and Teng's (2021) study provided additional evidence in favor of this claim on the influence of games on young children's mathematics knowledge.

Table 5 further indicates a significant difference ($p < .001$) in the pretest (74.13%) and posttest (88.88%) results of the students who utilized the Intego Card Game. This connotes that the utilization of the game allows the students to effectively grasp the concepts of addition and subtraction of integers. The students' performance improved from "did not meet expectation" to "very satisfactory" classification. The findings of this study are consistent with earlier research on the value of games in enhancing student performance in math lessons (Bayeck, 2020; Kobayashi, 2021). According to Alonso-Fernández et al. (2020), educational games increase students' attention and focus, which enhances their learning.

**3.6 Difference in the Posttest Results of the Two Groups of Students in Addition and Subtraction of Integers**
Table 6 presents the data identifying the difference in the post-test results of the two groups of students. Using a t-test for independent data, the study found that the p-value (0.458) is greater than the level of significance (0.05).

This result means no significant difference can be seen between the posttest performances of the two groups of students who utilized the Integer Math Maze and Intego Card Game.

**Table 6.** Difference in the posttest results of the two groups of students in addition and subtraction of integers

| GROUP | POSTTEST | D | T-VALUE | P-VALUE | REMARK |
|---|---|---|---|---|---|
| Integer Math Maze (n = 21) | 87.02 | | | | |
| | | 1.86 | 0.749 | 0.458 | Not significant |
| Intego Card Game (n = 20) | 88.88 | | | | |

Level of significance = 0.05

This result signifies that the Integer Math Maze is as effective as the Intego Card Game in learning the addition and subtraction of integers. Similarly, Chong et al. (2022) found that non-digital card games are effective in improving students' performance in the operations of integers. They further added that non-digital card games can help students perform better when it comes to integer operations. The increase in the performance of the students after the utilization of the Integer Math Maze and Intego Card Game might have resulted from the kind of cooperation, motivation, and group activities experienced by the students, which encourage student-centered learning. According to Lasut and Bawengan (2020), game-based instruction is a method of teaching mathematics that enhances learning efficiency through student-centered learning activities and provides a balance between traditional classroom instruction and educational games.

### 3.7 Relationship between the Level of Students' Enjoyment of the Game-Based Instruction and Their Posttest Performance

Table 7 reveals a significant relationship ($p = 0.047 < \alpha = 0.05$) between the level of students' enjoyment of using the Integer Math Maze and their post-test performance. This means that students who enjoy the Integer Math Maze tend to perform better in addition and subtraction of integers. This signifies that game-based instructions can stimulate and motivate the students to participate more actively in the learning process which leads to more effective comprehension (Khairuddin & Mailok, 2019). The game-based strategy creates an engaging, dynamic, and fun environment while learning (Alonso-Fernández et al., 2020).

**Table 7.** Relationship between the level of students' enjoyment of the game-based instruction and their post-test performance

| POSTTEST PERFORMANCE AND LEVEL OF ENJOYMENT IN USING… | $R_S$ | P-VALUE | REMARK |
|---|---|---|---|
| Integer Math Maze (n = 21) | 0.438 | 0.047 | Significant |
| Intego Card Game (n = 20) | 0.233 | 0.321 | Not significant |

Level of significance = 0.05

Meanwhile, no significant relationship was found ($p = 0.321 > \alpha = 0.05$) between the level of students' enjoyment of using the Intego Card Game and their post-test performance. This connotes that regardless of the level of enjoyment of the students in learning addition and subtraction of integers through the Intego Card Game, their post-test performance does not vary. This finding, however, does not have a negative connotation considering that the level of the students' enjoyment is generally "very high," as indicated in Table 4. Due to the less variation in the students' responses, a non-significant correlation appears. However, Singh et al.'s (2021) findings indicated that as a result of students' enjoyment of the use of the card game, they improved their numeracy abilities. Hence, learning proceeds more effectively when there is joy, fun, and involvement in the process.

## 4.0 Conclusion

Mathematical concepts introduced through games increase students' engagement, enhance their motivation to learn, and enrich their collaboration and social interaction. Students who exhibit these traits tend to pay more attention to the lessons, so they grasp the concepts of integers embedded in the mechanics of the game. Everyone desires to win, motivating the students to become familiar with the various rules of integers. Every time they lose, the more they strive to understand how the game works, which leads them to the mastery of the different operations. This learning process further facilitates long-term retention of knowledge and reinforces learning over time. Moreover, games can become sustainable tools for teaching and learning integer operations by providing engaging and effective learning experiences for students while supporting teachers in their instructional efforts. Once both teachers and learners grasp the indispensability of the game, they will love it thereby ensuring that they will continue to use it to simplify the teaching and enjoy the learning. With the information provided by this

study, it is time for educators and curriculum implementers to look at students' performance with game-based instruction to scaffold students' difficulties in the different operations of integers.

## 5.0 Contributions of Authors

The authors of this study have equal contributions to the completed version of the manuscript.


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## 7.0 Conflict of Interests

When it comes to this study, the authors have no conflicts of interest.


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