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ZOLTAN DIENES' USE OF MANIPULATIVES IN TEACHING PROBABILITY: AN EXPERIMENT

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Abstract

This study aimed to determine the effectiveness of Zoltan Dienes' uses of manipulatives as an instructional strategy in solving probability problems. A quasi-experimental design was utilized in the study. The study was conducted at the Monkayo National High School during the second semester of the school year 2025-2026. Mean was used to calculate class proficiency to determine the competency level of the research subjects. Based on the computed mean of the pretest scores, both groups had the same baseline of competency and were believed to be comparable. To test the significant difference, paired and independent t-tests were employed as statistical tools. The results indicated that there was a significant improvement in using direct interactive instructional strategy in Grade 11 Joaquin as the control group. Also, the Zoltan Dienes' use of manipulatives as an instructional strategy improved the Grade 11 Legaspi students' scores in the assessment higher than the average mean of the control group. In addition, these key findings suggest that the use of the mentioned manipulatives as an instructional strategy fared better than the direct interactive instruction. Therefore, it was recommended that teachers use this as an alternative strategy in the classroom setting.

Keywords: mathematics, Zoltan Dienes' manipulative, direct interactive instructional strategy, probability, quasi-experimental

INTRODUCTION

Background of the Study

Mathematics achievement in probability serves as an important indicator of the learners' ability to comprehend uncertainty and aids them in making rational choices in real-life situations. Despite its significance, many students continue to demonstrate low achievement in this area. This is because probability involves abstract concepts and random events that require higher-order thinking and reasoning skills, making it difficult for learners to fully grasp. Hence, students often find difficulties solving probability-related questions and reasoning and contextualizing the fundamentals. Because of this, students' performance indicates a need to implement better teaching techniques to enhance students' performance. According to Rahman and Ahmar (2017), studies have shown that strategies emphasizing active engagement and concrete learning experiences can significantly enhance students' mathematics achievement.

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In Southeast Asia, improving mathematics achievement in probability remains a continuing challenge. Research conducted in Indonesia, many students exhibit low levels of probabilistic thinking, which causes lower performance in Mathematics (Rohim, 2019). Students struggle to interpret random events and find context for both experimental and theoretical probabilities and subsequently apply probability laws to problem-solving. These issues manifested prominently as poor learning outcomes and highlighted the need for various instructional innovations drawn from research to develop and improve the conceptual understanding of learners.

The low achievement in probability in mathematics is also seen in the Philippines. Quinio and Cuarto (2023) in their study pointed out that many learners have difficulty in applying the concepts of probability correctly because of the memorization and lack of understanding to solve probability related tasks. This dependence restricts their reasoning and ability to implement concepts in various real-life scenarios. Such findings show an urgent need to shift the focus of teaching approaches to learner-centered, and focus on concepts, teaching.

At the local level, this concern is observed among Grade 11 students at Monkayo National High School. Teachers reported that some students can solve certain problems with routine practice, but fail to demonstrate reasoning for their solutions, and fail to acknowledge and associate probability concepts with real-life situations. The situational gaps of state of knowledge and pedagogic gaps of knowledge and understanding negatively impact the achievement of students in this field of Mathematics.

Given this situation, the researcher feels that the lack of knowledge and understanding of pedagogy is a gap that requires a huge pedagogical shift. Hence, there is an urgent need for a shift from the current instructional approach to one that is more productive and enjoyable to the students to improve the students' achievement in Mathematics. One promising approach is the use of manipulatives and hands-on learning experiences that provide students with a concrete and meaningful way to explore probability concepts. These approaches have the potential of bridging the gap between abstract concepts and real-life experiences and ultimately enhancing students' comprehension and boosting their mathematics achievement in probability.

Purpose of the Study/Research Questions

This action research sought to answer the following objectives:

1. What is the competency level of the students in their pretest scores in terms of Direct-Interactive Instruction?
2. What is the competency level of the students in their pretest scores in terms of Zoltan Dienes' Use of Manipulatives?
3. What is the competency level of the students in the posttest scores in terms of Direct-Interactive Instruction?
4. What is the competency level of the students in the posttest scores in terms of Zoltan Dienes' Use of Manipulatives?
5. Is there a significant difference between the pretest scores of the control group and experimental group?
6. Is there a significant difference between the pretest and posttest scores of the control group?
7. Is there a significant difference between the pretest and posttest scores of the experimental group?
8. Is there a significant difference between the posttest scores of the control and experimental groups?

METHODOLOGY

Participants/ Respondents/ Informants/ Subjects

The subjects of the study were 80 Grade 11 students, with 40 students assigned to the experimental group and 40 students to the control group. There were only two sections in the grade level, namely Grade 11-Legaspi and Grade 11-Joaquin, which served as the experimental and control groups, respectively. To ensure objectivity in the selection process, sections were chosen through random sampling, giving all students an equal chance of being included in the study. This approach minimizes selection bias and ensures that the results accurately reflect the impact of Zoltan Dienes' manipulatives on students' achievement in probability.

Data Gathering Method

The data collection for this quasi-experimental study was conducted at Monkayo National High School – Senior High Department, located in Davao de Oro, during the academic year 2025–2026. Prior to the implementation of the study, the researcher first secured an Ethics Certificate from the Ethics Review Committee and an endorsement letter from the Dean of the Graduate School. Furthermore, the researcher strictly complied with all ethical standards and approval protocols set by the Department of Education. A formal letter of request and authorization to conduct the study was submitted to the Office of the Schools Division Superintendent of Davao de Oro. After the approval, the request was endorsed to the District Head of Monkayo West and then to the Principal IV of Monkayo National High School, where the pilot testing and actual implementation took place.

Upon securing all necessary approvals, the researcher proceeds with the preparation of instructional materials and assessment tools. These included a lesson plan and pretest-posttest questionnaires. Although the lesson plan has already undergone quality assurance by the Department of Education, it was further reviewed and validated by the research adviser and external content experts to ensure its alignment with Zoltan Dienes' use of manipulatives and the prescribed learning competencies of the K to 12 curriculum.

Data Analysis Plan

The study employed a two-group pretest-posttest quasi-experimental design involving two intact Grade 11 sections: one experimental group and one control group. Before the instructional intervention, both groups administered a 30-item pretest under standardized conditions and within a 30-minute time limit. This test assessed students' baseline understanding of probability distribution based on the competencies outlined in the DepEd curriculum guide. During the intervention period, the experimental group was taught using Zoltan Dienes' use of manipulatives, which is integrated with the six stages of his mathematical learning theory. In contrast, the control group received instruction through a direct-interactive instruction. After the series of lessons, a posttest was administered to both groups.

Furthermore, all test results were collected, recorded, and analyzed using appropriate statistical techniques to determine the effectiveness of Zoltan Dienes' use of manipulatives. To ensure comparability and control for extraneous variables, both groups were subjected to standardized test conditions, procedures, and environments. The final analysis focused on measuring the

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improvement in student achievement from pretest to posttest and comparing the performance of the experimental and control groups to evaluate the instructional strategy's impact on learning outcomes. The researchers used mean to determine the average achievement of the two groups based on their test scores. Paired t-test and independent-test were used as test of significance,

RESULTS AND DISCUSSION

The chapter shows the obtained data and analyzes the results in response to the research questions.

Competency level of the Students in their Pretest Scores

This section presents the competency level of the students in terms of their pretest scores. Table 2 and 3 shows the performance of the control and experimental group in terms of their mean, class proficiency and competency level

Table 1: Competency level of the Students in their Pretest Scores in terms of Direct Interactive Instruction

Test	No. of Students	Mean	Class Proficiency	Competency Level
Grade 11-Joaquin (Control)	40	9.37	31.23%	Low Mastery

Table 1 presents the pretest scores of the students applied with direct interactive strategy. The Grade 11 Joaquin, the control group with 40 students, exhibits low mastery when it comes into their competency level. With the mean of 9.37 and class proficiency of 31.23%, this indicates that during at the pretest stage, the students demonstrate limited conceptual understanding and not enough skillset to solve problems involving probability. This further suggests the need for instructional support to improve their competency level.

Table 2: Competency level of the Students in their Pretest Scores in terms Zoltan Dienes' Manipulatives

Test	No. of Students	Mean	Class Proficiency	Competency Level
Grade 11-Legaspi (Experimental)	40	9.70	32.33%	Low Mastery

Table 2 provides the performance data of the experimental group as the subject of the study. The strategy being applied is the Zoltan Dienes' Manipulatives with the goal of improving the students' performance. Based on the table, the mean of the experimental group consisted with 40 students obtained a 9.70 mean score. This corresponds to a class proficiency of 32.33 percent, which is categorized as Low Mastery. The results indicate that students in this group struggled in solving problems involving probability. Similar to the control group, the finding suggests for the need of instructional strategy to supplement the learning of the students.

The average scores of the students in their pretest yielded to low mastery level. With this descriptive interpretation, it indicates that students started in the same baseline of competency. With a slight mean difference, the two groups were both comparable. Based on these results, the Grade 11 learners struggled in solving probability problems.

Furthermore, a study conducted by Memnun et al. (2019) revealed that students have difficulty in solving probability problems and find it hard to apply the concepts in the problems. They also reported that students had difficulty in understanding probability involving sample spaces, probability of events, and interpreting situations about such as discrete event and independent event. Tunc (2006) stated that with these misconceptions, students confused independent, dependent, and discrete events with one another often leading to give an incorrect solution. The same problems were observed in the study conducted by Andam et al. (2025) who noted that probability problems were very difficult to learn and conceptualize.

Competency level of the Students in their Posttest Scores

This part reveals the competency level of the two groups that are the study's subjects. This ought to address the third and fourth statement of the problem, which is to determine their academic performance level. Table 4 and 5 show the mean scores of the posttests of the control and experimental groups.

Table 3: Competency level of the Students in their Posttest Scores in terms of Direct Interactive Instruction

Test	No. of Students	Mean	Class Proficiency	Competency Level
Grade 11-Joaquin (Control)	40	22.05	73.50%	Near Mastery

The table presents the competency level of Grade 11–Joaquin students in their posttest scores in terms of direct interactive instruction. It shows that the control group consisted of 40 students who obtained a mean score of 22.05. This corresponds to a near mastery competency level with a class proficiency of 73.50%. These data indicate that students demonstrated deep understanding of the subject being taught. Further, this strengthen the claim that the strategy used in the study is effective and help the students to achieve full mastery and enhance their problem-solving skills.

Table 4: Competency level of the Students in their Posttest Scores in terms of Zoltan Dienes' Manipulatives

Test	No. of Students	Mean	Class Proficiency	Competency Level
Grade 11-Legaspi (Experimental)	40	23.53	78.43%	Mastery

Highlighted in the table is the competency level of the students which is mastery level. With the mean of 24.53 and class proficiency of 78.43%, this suggest that the experimental group with a total number of 40 students, exhibits a positive performance with the Zoltan Dienes' Manipulatives as the strategy. These results indicate that the students demonstrated a high level of understanding of the lesson content, suggesting that the use of manipulatives effectively improved their learning and enabled them to achieve a higher level of competency.

The two groups had a competency level of near mastery and mastery. In terms of the mean score of the different groups, the experimental group outshined the control group with a minor difference of scores. It was also evident in the class proficiency of the Grade 11-Joaquin and Grade 11-Legaspi. The values indicated

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that after the experimental group received the Zoltan Dienes' use of manipulatives in probability problems, the students performed better that the students supplemented with direct interactive method.

Several studies mentioned about the effectiveness of the two interventions that were utilized. Nurdin (2020) reported that direct interactive study improved the students' performance in mathematics and raised their scores in solving mathematical assessments. On the other hand, Boggan et al. (2010) stated in their findings that the most valuable learning occurs when students actively construct their knowledge which is often accomplish through the use of manipulatives. Though both strategies employed improved the performance in probability of the students, the section employed with Zoltan Diene's manipulative fared better compared to the other section treated with direct interactive study.

Test Results of the Hypotheses

Tables 5, 6, 7, and 8 show the test of significance between the pretest and posttest within the same and different groups.

There is no significant difference between the pretest scores of the students who used the direct interactive instructional strategy and those of the students who used Zoltan Diene's uses of manipulatives as strategy.

Table 5: Comparison of Pretest Scores Between the Control Group and Experimental Group

Test	Mean	t-value	p-value	Remark	Interpretation
Grade 11-Joaquin (Control)	9.37	-0.741	0.461	Accept Ho	Not Significant
Grade 11-Legaspi (Experimental)	9.70				

The pretest scores revealed that Grade 11–Legaspi, as the experimental group, obtained a higher mean score of 9.70 compared to the control group, Grade 11–Joaquin, which had a mean score of 9.37. This shows that the experimental group performed slightly better than the control group. The independent sample t-test results yielded a t-value of -0.741 and a p-value of 0.461, which implies that there is no significant difference between the pretest scores of the control and experimental groups. Since the p-value is greater than the standard significance level of 0.05, the null hypothesis is accepted. This outcome indicates that both groups started with the same baseline of competency and are both comparable.

Moreover, direct interactive strategy as a strategy contributed to the learning of the students and somehow improved their learning in statistics. This method served as an effective tool in improving the academic performance of the students. This involved the common ways of teaching such as chalk and talk, visual aids, reporting and different activities that lead to a teacher and student interaction (Cielo et. al., 2019)

There is no significant difference between the scores of the pretest and posttest of the students who applied the direct interactive instructional strategy.

Table 6 shows the t-test results to determine if there is a significant difference between the means of the students in Grade 11 - Joaquin. This section is the control group of the study, and it was treated with direct interactive instructional strategies. The scores in their pretest and posttest were computed to determine the effectiveness of the treatment.

Table 6: The Control Group Results Before and After the Experiment

Test	Mean	t-value	p-value	Remark	Interpretation
Pretest		32.5	0.000	Reject Ho	Significant
Posttest					

Paired t-test as a tool is used to determine the significant difference between the pretest and posttest score of the students in Grade 11-Joaquin. As shown in the table, the mean score of the pretest is 9.39. After the treatment is used, which is the direct interactive strategy, the mean score of the control group increased into 22.05. Furthermore, with the t-value of 32.5 and p-value of 0.000, this statistically indicates that there is a significant difference between the pretest and posttest scores of the students in the control group. Thus, the data revealed that direct interactive as a strategy improved the mathematical performance of the students when it comes to solving probability problems leading to the rejection of the null hypothesis.

According to Oladayo (2012), students' achievement is positively impacted by direct interactive education. He suggested the use of direct interactive instruction in the teaching of mathematics in his research on direct and indirect approaches. Improved comprehension of mathematics seemed to require the help of teachers. This required being presented in all four corners of the classroom and assisting the students in the teaching and learning process. being receptive to their questions and willing to keep the kids involved in the conversation (Koskinen & Pitkaniemi, 2022).

There is no significant difference between the scores of the students' pretest and posttest when the Zoltan Diene's uses of manipulatives was applied as an instructional strategy.

The Grade 11-Legaspi students are the study's subjects, treated with the Zoltan Diene's uses of manipulatives. The aforementioned section is the study's experimental group, and their pretest and posttest scores are displayed in Table 8 to determine the significance level of the students' performance in solving probability problems.

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Table 7: The Experimental Group Results Before and After the Experiment

Test	Mean	t-value	p-value	Remark	Interpretation
Pretest	9.7	21.46	0.000	Reject Ho	Significant
Posttest	23.53				

The computed data for the comparison between the pretest and posttest scored of the Grade 11-Legaspi is shown in the table 8. This group is treated with Zoltan Diene's uses of manipulatives as an experiment to improve the students' mathematical performance when it comes to solving problems involving probability. A paired t-test is utilized to determine if there is a significant difference between their scores. Basing on the solved mean value, with a huge difference of 13.83, it signifies that the students' performance significantly improved. Additionally, given the p-value of 0.000 and t-value of 21.46, it solidifies the claims that there is a significant difference between the Grade 11-Legaspi students' scores in pretest and posttest. Therefore, the experimental intervention which is the Zoltan Diene's uses of manipulatives is effective as it improves the performance of the students in the experimental group.

According to Paliwal (2018), manipulatives are effective tools that aid the students in understanding probability, and it promote learning through tactile work and visual representation. Moreover, the use of manipulatives allowed the students to translate abstract concept to its corresponding concrete representation that help the students to solve the problems easier. This was further supported by Jones and Tiller (2017) in their study that to make abstract concept more accessible, the usage of manipulatives should be utilized in the classrooms. In this regard, Zoltan Diene's manipulatives should be an alternative tool as this strategy assisted the students in gauging the mathematical competency.

There is no significant difference between the posttest scores of the students who used the direct interactive instructional strategy and those of the students who used Zoltan Diene's uses of manipulatives as strategy.

The posttest scores of the two different groups are assessed after the treatments are completed. The control group (Grade 11-Joaquin) is introduced with a direct interactive instructional strategy, while the experimental group (Grade 11-Legaspi) is assisted by the Zoltan Diene's uses of manipulatives. Table 5 shows the presentation of the scores of the different groups.

Table 8: Comparison of Posttest Scores Between the Control Group and Experimental Group

Test	Mean	t-value	p-value	Remark	Interpretation
Grade 11-Joaquin (Control)	22.50	-2.314	0.023	Reject Ho	Significant
Grade 11-Legaspi (Experimental)	23.53				

The posttest scores revealed that Grade 11-Legaspi as experimental group obtained a higher mean score compared to the control group which is the Grade 11-Kasilag. With a mean score of 23.53 and 22.50 respectively, this shows that the experimental group performed better compared to the control group. The independent sample t-test results yielded a t-value of -2.314 and p-value of 0.023 which implies that there is a significant difference between the posttest scores of the control and experimental group. Moreover, since the p-value is less than the standard significance level of 0.05, the null hypothesis is rejected. This outcome presents that although both strategies, namely the direct interactive strategy and Zoltan Diene's uses of manipulatives as strategy, improved the students' mathematical performance in dealing with probability problems, the students in experimental group fared better than the control group.

Problem solving was an important skill that one must possess. It was one of the important components in dealing with real-life problems and applications (Azizah et.al., 2021). Probability was the most commonly hard problems encountered by the students in their daily activities (Sari et al., 2024). As a result, several strategies were performed by the teachers to reinforce the learning inside the classroom. In this study, among the two methods that were experimented with to determine their effectiveness, Zoltan Dienes' use of manipulatives as an instructional strategy outperformed the direct interactive instruction (Paliwal, 2018). This result was also strengthened by Lantz and Miller (2019), who stated that manipulatives were beneficial to students to help them grasped the abstract mathematical concepts

CONCLUSION

The data presented in the analysis provided the academic performance of the two groups in solving probability problems. The findings revealed that the control and experimental groups showed the same level of competency before the experiment period. Moreover, both instructional strategies, namely the direct interactive instructional strategy and the Zoltan Diene's manipulatives, showed a significant improvement in the test scores of the students. Consequently, the findings suggest that both treatments were effective in enhancing the problem-solving skills of the students in solving probability problems. Nevertheless, the innovative strategy namely the Zoltan Diene's manipulatives performed better as the comparison of both posttest scores yielded to significant difference.

Overall, the data revealed that the Zoltan Diene's manipulatives outperformed the direct interactive strategy in terms of the scores of the students. It means to say that the adapted strategy had a positive impact in improving the competency level of the students. Hence, the strategy employed in the experimental phase was an effective strategy that can enhance the students' ability to solve probability problems involving sample spaces, discrete, dependent and independent events.

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RECOMMENDATIONS

Learners. Zoltan Diene's use of manipulatives, based on the data, is deemed an effective instructional strategy, particularly in solving probability problems. It is recommended to adopt this method as an alternative strategy to classroom instructions to help the students.

Teachers. Zoltan Diene's use of manipulatives covers a wide area in the field of mathematics, not just in sample spaces, discrete, dependent and independent events. It is encouraged that the mathematics teachers utilize this method not just in the mentioned lesson, but also on the other fields like algebra.

Curriculum designers. It is suggested that the curriculum designers consider the use of Zoltan Diene's use of manipulatives to be embedded in the school curriculum to develop tactile learning experience and visual representation to enhance the learning experience of the students*Future Researchers.* They are encouraged to conduct a study to further check the effectiveness of Zoltan Diene's use of manipulative as an instructional strategy. A qualitative study is also recommended to explore the impact of the introduced method in primary school.

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