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Creative Thinking Ability of Vocational School Students in Contextual Trigonometry Learning Using Futsal

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ABSTRACT

This study explores the limited use of contextual approaches in fostering creative thinking in trigonometry learning. This study aims to determine the difference in creative thinking test scores of vocational high school students before and after learning trigonometry in the context of futsal. This study used a quantitative method with a pre-experimental design and a one-group pretest-posttest form, with 27 tenth-grade students as the sample. The instrument used was a mathematical creative thinking ability test with futsal-contexted trigonometry material. Data analysis included descriptive statistics, the Shapiro-Wilk normality test, the Wilcoxon test, and N-Gain. Descriptive results showed that creative thinking ability was in the moderate range (63%) and increased from 41.81 to 77.26 between the pretest and posttest. The Wilcoxon test showed that Ho was rejected and Ha accepted, indicating a difference in creative thinking skills before and after the treatment (0.000 < 0.05), with an N-Gain score of 0.77. Therefore, it was concluded that the futsal sports context in trigonometry material yielded good results, with a noticeable difference before and after classroom learning.

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1. INTRODUCTION

Mathematics is an academic field that demands problem-solving skills, which are crucial for addressing the challenges of the twenty-first century. In essence, mathematics is a science that employs formal, abstract, and deductive reasoning [1]. Four essential skills for the 21st century are creative thinking, critical thinking, communication, and collaboration [2]. In this case, creative thinking skills, which enable students to think outside the box, are required. Students are asked to come up with new ideas as part of the problem-solving process in a creative, novel, and unique way [3]. The ability to think creatively and creativity are interrelated; creativity means being able to come up with ideas that are rare and not yet widely known [4]. If problems are solved creatively, it is hoped these measures can positively impact learning outcomes.

In today's digital age, students are often referred to as Gen Z [5]. The Gen Z era has many differences in thinking, behavior, culture, and habits from previous generations. Students in Gen Z today are more inclined to solve problems instantly, creatively, and adaptively, without overthinking or getting caught up in the process, because they are vulnerable to the negative influences of social media [6]. In fact, creating creative ideas requires the willingness and ability to go through each stage of the process, especially in learning abstract mathematics [7]. Therefore, high-level thinking skills are required to solve problems, which naturally involve creativity in revisiting mathematical ideas and concepts developed to solve them, especially in mathematics learning, which is known as creative thinking.

Students' capacity to experiment with alternative approaches to thinking and solving mathematical issues is known as mathematical creative thinking [8]. Research shows that students' creative thinking skills in mathematics learning remain underdeveloped [9]. This is an issue that needs further attention, as creative thinking skills are very important for exploring mathematical thinking.

Mathematical creative thinking skills include fluency, flexibility, originality, and elaboration [8]. Flexibility is the capacity to generate several solutions, whereas fluency is the ability to generate a variety of replies; originality is the process of generating unique and unusual ideas; and elaboration is the ability to elaborate on answers using one's abilities [10]. This is reinforced by previous research that most mathematics learning in the classroom does not develop critical and creative thinking skills [11]. As simple as simplifying algebraic expressions, finding connections between mathematics and real-world contexts certainly requires deep thinking [12].

One theory of mathematics learning that connects real-world contexts with mathematics is RME (Realistic Mathematics Education). Mathematics learning using the RME approach can begin by encouraging students to think using informal reasoning, which can shape their view of mathematics with formal questions [13]. RME emphasizes the use of real, relevant contexts from everyday life to help students build a deep understanding of mathematical concepts [14].

The application of real-world contexts can enable students to develop high-level thinking and problem-solving skills in the field of sports. Sports is a field of study that is very popular among students because it involves indoor and outdoor activities and is important for physical health [15]. Previous studies have applied sports contexts to mathematics, such as karate [16], Volleyball [17], and badminton [18]. However, studies that integrate sports context—particularly in this case, futsal—into trigonometry instruction remain limited. In an effort to achieve the 2030 SDGs in quality education, applying the sports context in mathematics can serve as the main framework for developing a mathematics teaching curriculum, offering a new way to collaborate between the fields of sports science and mathematics that was previously rare. Developing an up-to-date curriculum can improve the quality of teaching [19].

The context of futsal is used in this study because it has elements related to trigonometry in terms of points, angles, and path lengths that are related to the material on right-angled triangles in trigonometry learning. Trigonometry is a branch of mathematics that deals with the relationship between angles and the ratio of side lengths [20]. Previous research found that students' learning outcomes in trigonometry were low because they found it difficult to solve trigonometry problems [21]. The difficulties students face may be due to a lack of variety in the media educators use to deliver learning materials [22]. Thus, applying the futsal sports context is expected to serve as a differentiator and provide solutions to the problems and difficulties students face in learning trigonometry.

Existing research on creative thinking ability in trigonometry mostly discusses trigonometry in an abstract context or general problems that are not specific to trigonometry. No previous studies have specifically integrated a sports-related context, particularly futsal, into trigonometry learning, with the aim of developing students' creative thinking abilities in futsal. Therefore, this study is necessary to compare the creative thinking abilities of vocational high school students before and after applying trigonometry training in a futsal setting. It is hoped that this study will serve as a new and beneficial innovation in mathematics education by integrating sports-related contexts into Indonesian mathematics curricula.

2. METHOD

Pre-experimental design in the form of a one-group pretest-posttest is used in this study's quantitative methodology. To determine whether there is a difference in outcomes before and after the therapy, the study group will be measured twice: once before treatment and once after [23].

The research design is illustrated in Table 1 below [24].

Table 1. Research Design Scheme

O_1	X	O_2

Description :

X : contextual trigonometry learning treatment in futsal

O_1 : creative thinking skills pretest

O_2 : posttest on creative thinking skills

This study did not employ a control group, it was conducted in a single class. The study population consisted of 10th-grade students at a private vocational school in Bekasi. A total of 27 students majoring in pharmacy were selected as the sample because their final evaluation scores fell into the lowest category. Data collection techniques included pre- and posttests of creative thinking ability before and after learning trigonometry in the context of futsal, consisting of four essay questions. The creative thinking ability test instrument used in this study consists of four items designed to measure the following indicators: fluency, flexibility, originality, and elaboration, all of which have been validated and found to be reliable by expert validators, namely high school mathematics teachers, mathematics education lecturers, and physical education teachers who are experts in the field of futsal.

Data analysis in this study used SPPP 27.0 software, and the Shapiro-Wilk normality test was performed. The testing criteria used in the Shapiro-Wilk test were an analysis conducted to assess the data distribution in relation to the research hypothesis. If the Sig. value was < α, then Ho was rejected, meaning that the data was not normally distributed. Conversely, if the Sig. value was ≥ α, then Ha was accepted, meaning that the data was normally distributed [25]. The normality test results indicated that the data were not normally distributed; hence, the Wilcoxon nonparametric test was used. The hypothesis in the Wilcoxon nonparametric test is as follows.

Ho : There was no difference between the pretest and posttest of creative thinking skills.

Ha : There is a difference between the pretest and posttest of creative thinking skills.

The Wilcoxon test was conducted in SPSS at the 0.05 significance level. The decision was made that if the significance value was < 0.05, Ho was rejected and Ha was accepted, and if the significance value was > 0.05, Ho was accepted and Ha was rejected.

The effectiveness of applying the futsal context to trigonometry learning with creative thinking skills was tested using the N-Gain formula. Gain is the difference between the pre- and post-treatment values [24]. Formulas for calculating N-Gain include:

$$N - Gain = \frac{Score\ Posttest - Score\ Pretest}{Score\ Ideal - Score\ Pretest} \quad 1)$$

With the N-Gain criteria in Table 2 below [26].

Table 2. N-Gain Category

N-Gain Value	**Category**
0.70 ≤ g ≤ 1.00	High
0.30 ≤ g < 0.70	Moderate
0.00 < g < 0.3	Low
g = 0.00	No Increase
-1.00 ≤ g < 0.00	Decrease

3. RESULTS AND DISCUSSION

3.1. Results

The results of the pretest and posttest of creative thinking skills from the application of futsal-based trigonometry learning are presented in the descriptive statistics in Table 3 below.

Table 3. Descriptive Statistics Results

	Pretest	Posttest
Average	41.81	77.26
Standard Deviation	21.037	20.654
Minimum Value	0	25
Maximum Value	75	100

Based on Table 3, the pretest and posttest data for 27 students in Grade X Pharmacy show that the highest pretest score was 75 and the highest posttest score was 100, while the lowest pretest score was 0 and the lowest posttest score was 25. The pretest mean was 41.81, and the posttest mean was 77.26, with pretest and posttest standard deviations of 21.037 and 20.654, respectively. Table 4 contains the Shapiro-Wilk normality test before conducting the difference test on the two research variables. Normality was checked first to ensure that the parametric or nonparametric assumptions were met.

Table 4. Hasil Uji Normality Test Results

	Shapiro Wilk		
	Statistic	df	Sig.
Pretest	.940	27	.124
Posttest	.898	27	.012

The results of the Shapiro-Wilk test indicate a normally distributed distribution if the Sig. value is greater than 0.05; if it is less than 0.05, the data is not normally distributed. In this situation, the test results reveal a pretest Sig. > 0.05 while the posttest Sig. < 0.05, therefore Ho is approved, which suggests the data is normal for the pretest. However, Ho is denied because the posttest data are not normally distributed. As a result, parametric tests are not applicable in further testing. If the data are not normally distributed, the Wilcoxon Signed Ranks test is used to assess the difference in creative thinking ability test scores before and after treatment, as shown in Table 5.

Table 5. Ranks pretest and posttest creative thinking ability

		N	Mean Ranks	*Sum of Ranks*
Pretest - Posttest	Negative Ranks	0	.00	.00
	Positive Rank	25	13.00	325.00
	Ties	2		
	Total	27		

Based on Table 5, regarding the pretest and posttest ranks of creative thinking skills in trigonometry learning with a futsal context from 27 students who took the test, there were 0 negative ranks, meaning that no students experienced a decrease in scores, then 25 students in positive ranks experienced an increase in scores, with an average increase of 13.00 and an average total of 325.00. There were also 2 ties between the students' pretest and posttest scores.

The results of the Wilcoxon statistical test in answering the hypothesis of differences before and after the treatment are presented in Table 6.

Table 6. Wilcoxon Statistical Test

	Pretest - Posttest
Z	-4.381
Asymp. Sig. (2-Tailed)	.000

Table 6 presents the results of the Wilcoxon test of the pretest and posttest data for creative thinking skills, with a Z value of -4.381 and a significance value of 0.000 (sig. < 0.05), indicating that Ha is accepted and Ho is rejected. This indicates a difference in creative thinking skills between the pretest and posttest, before and after the trigonometry learning treatment in a futsal context. After the hypothesis was obtained, the test results were used to determine the effectiveness using N-Gain, as presented in Table 7.

Table 7. N-Gain Data Test

Description	**N-Gain Value**	**Category**
Average	0.77	High

The N-Gain results in Table 7 show an N-Gain value of 0.77, which is classified as high. This indicates an increase in students' creative thinking skills before and after the implementation of futsal-based trigonometry learning. Thus, it can be concluded that students' creative thinking skills improved through trigonometry instruction, with a high level of achievement.

3.2. Discussion

Based on the descriptive research results, there was a significant difference between the pretest and posttest averages. There was an increase from 41.81 before treatment to 77.26 after treatment, achieving 35.45 points. This could be due to the opportunity for students to develop their creative thinking ability in mathematics. The researcher conducted a Wilcoxon test to assess differences before and after the futsal-based trigonometry learning treatment. The results of the study showed a significance level of 0.000, which is less than 0.05, indicating that the application of learning or treatment in a futsal context within trigonometry material can improve students' creative thinking skills. This is in line with previous research findings, which stated that students' mathematical abilities with the application of a real context, namely sports, were better before it was applied [27].

The study's findings revealed an increase in all indices of creative thinking abilities before and after treatment, including fluency, flexibility, originality, and elaboration. This increase was inseparable from the application of the RME approach, which presented real-world learning contexts and encouraged students to work independently and in groups using student worksheets (LKPD) [28].

Overall, the post-treatment score for students in the moderate category was 63%, higher than those in the high and low categories. On the first indicator of creative thinking ability, namely fluency, students provided accurate answers fluently and in accordance with their own freedom of thought. The findings for the Fluency indicator showed that 93% of students understood the test questions. Then, on the flexibility indicator, students achieved a 70% score, indicating that some students answered in different ways, while others did not show correct answers. On the third indicator, originality, the percentage obtained was 71%. Some students were able to answer correctly, while others still felt difficulty and confusion with the solution because they could not find other alternative methods [10]. This is demonstrated by the following students' answers in the intermediate category.

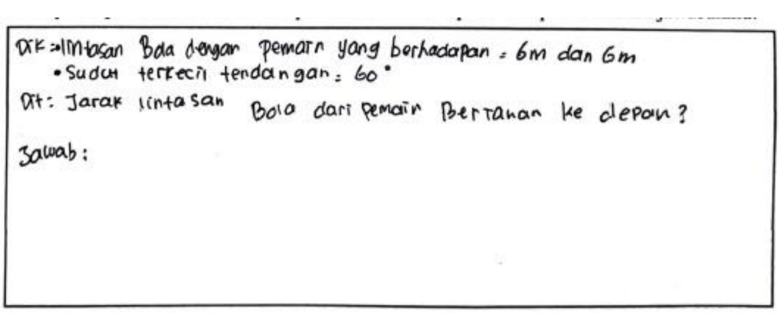


Figure 1. Answers from students in the intermediate category

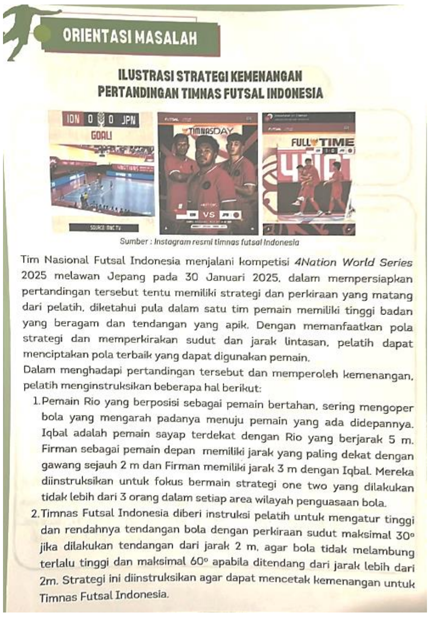
Based on Figure 1, students only wrote down what they knew and what was asked on the answer sheet, but did not continue to the solution. When the researcher explored this through a brief interview, the students felt confused, forgetful, and careless, and the examples in the previous LKPD guided them. This led the students not to find alternative ways to solve the problems in the questions [10]. This is reinforced by the opinion of Dwidarti et al., who explain that when working on story problems, students often lack thoroughness in reading and understanding each sentence, including recognizing existing information, determining what is being asked, and choosing the appropriate solution steps [29]. Meanwhile, in the elaboration category, students achieved a 80% rate, as determined by the researcher, and showed an increase from the pretest to the posttest.

Based on these results, it is possible to conclude that the use of futsal-based learning in trigonometry not only improves students' creative mathematical thinking but also allows them to develop a range of creative thinking skills holistically. The ability to manipulate different elements to discover new concepts includes creative analogical reasoning [30].

The subsequent N-Gain calculation yielded a value of 0.77, indicating that the students were in the high category. The value obtained indicates that the effective application of trigonometry in the context of futsal greatly helped students by integrating mathematics with sports science [31].

In the context of real mathematics, better known as the Realistic Mathematics Education (RME) approach, and applied to research tools using the problem-based learning (PBL) model, emphasis is placed on solving real problems in a more structured manner by understanding the problems in the questions and trying to find solutions through creative thinking analysis so that students can more easily relate real concepts to situations they encounter in their daily lives. where, in its application, teachers act as facilitators, applying PBL syntax and the RME approach, enabling students to demonstrate greater creativity [32]. The context of futsal here also has a profound meaning for them, because not only do they understand the initial concepts theoretically, but they also have a real picture, supported by video illustrations of Indonesian national futsal team players, during several learning sessions [33].

The learning process in this study consisted of six meetings, with six learning objectives and two separate meetings for pretests and posttests. The learning process lasted for 2 lessons, each lasting 90 minutes, beginning with an introduction, familiarization, motivation, questions from a video of the Indonesian national futsal team, explanation of learning objectives, problem orientation, organization of students for learning, presentation of results, conclusions, and reflection. Overall, learning was conducted in heterogeneous groups using PBL (problem-based learning). Research by Huda and Nur shows that PBL improves students' mathematical abilities [34]. The issues presented by students in groups for discussion regarding illustrations of futsal games by the Indonesian national team are tailored to each meeting's learning objectives. Figure 2 below illustrates the Indonesian national futsal team's winning strategy, as presented in the problem orientation in the LKPD.



ORIENTASI MASALAH

ILUSTRASI STRATEGI KEMENANGAN PERTANDINGAN TIMNAS FUTSAL INDONESIA

Sumber : Instagram resmi timnas futsal Indonesia

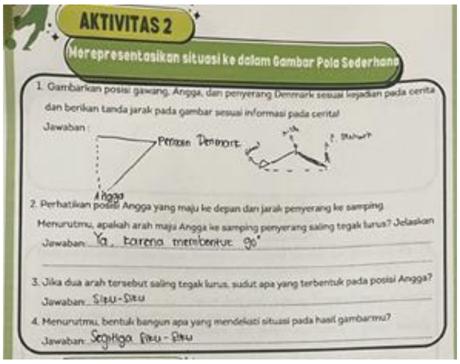
Tim Nasional Futsal Indonesia menjalani kompetisi *4Nation World Series* 2025 melawan Jepang pada 30 Januari 2025, dalam mempersiapkan pertandingan tersebut tentu memiliki strategi dan perkiraan yang matang dari pelatih, diketahui pula dalam satu tim pemain memiliki tinggi badan yang beragam dan tendangan yang apik. Dengan memanfaatkan pola strategi dan memperkirakan sudut dan jarak lintasan, pelatih dapat menciptakan pola terbaik yang dapat digunakan pemain.

Dalam menghadapi pertandingan tersebut dan memperoleh kemenangan, pelatih menginstruksikan beberapa hal berikut:

1. Pemain Rio yang berposisi sebagai pemain bertahan, sering mengoper bola yang mengarah padanya menuju pemain yang ada didepannya. Iqbal adalah pemain sayap terdekat dengan Rio yang berjarak 5 m. Firman sebagai pemain depan memiliki jarak yang paling dekat dengan gawang sejauh 2 m dan Firman memiliki jarak 3 m dengan Iqbal. Mereka diinstruksikan untuk fokus bermain strategi one two yang dilakukan tidak lebih dari 3 orang dalam setiap area wilayah penguasaan bola.
2. Timnas Futsal Indonesia diberi instruksi pelatih untuk mengatur tinggi dan rendahnya tendangan bola dengan perkiraan sudut maksimal 30° jika dilakukan tendangan dari jarak 2 m, agar bola tidak melambung terlalu tinggi dan maksimal 60° apabila ditendang dari jarak lebih dari 2m. Strategi ini diinstruksikan agar dapat mencetak kemenangan untuk Timnas Futsal Indonesia.

Figure 2. Problem Orientation Display on LKPD

In Figure 2, students are asked to read and analyze real-life situations in the field regarding winning strategies for kicking the ball into the goal from several possible angles and distances. Students are then asked to complete activities 1, 2, and 3 to solve the given problems. In the first meeting, students were asked to analyze the triangular elements in the futsal playing pattern on the field shown in the story illustration in Figure 3 below.



AKTIVITAS 2

Merepresentasikan situasi ke dalam Gambar Pola Sederhana

1. Gambarkan posisi gawang, Angga, dan penyerang Denmark sesuai kejadian pada cerita dan berikan tanda jarak pada gambar sesuai informasi pada cerita!
Jawaban :

2. Perhatikan posisi Angga yang maju ke depan dan jarak penyerang ke samping. Menurutmu, apakah arah maju Angga ke samping penyerang saling tegak lurus? Jelaskan
Jawaban: Ya, karena membentuk 90°

3. Jika dua arah tersebut saling tegak lurus, sudut apa yang terbentuk pada posisi Angga?
Jawaban: Siku-Siku

4. Menurutmu, bentuk bangun apa yang mendekati situasi pada hasil gambarmu?
Jawaban: Segitiga Siku-Siku

Figure 3. Results of the LKPD answers for the first meeting group

In Figure 3, students, in groups, analyze the patterns formed among three players, which are illustrated in the problem orientation of the first learning session. The problem orientation directs students to understand that a right triangle pattern can form when the players' positions are perpendicular to each other and form a 90-degree angle. In sessions 2 and 3, students were introduced to the ratios of angles in right-angled triangles, including sin, cos, tan, cosec, sec, and cotan. During the learning process, students were very active and enthusiastic when given a group learning system with a sports context, which was also their first experience in learning [35].

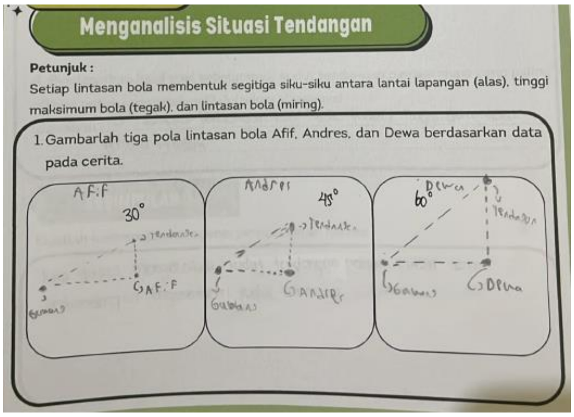


Figure 4. LKPD Answer Results for the fourth meeting group

In Figure 4, which shows the results of the fourth meeting's LKPD answers, students began analyzing the angle of the kick and understood the special angles that could be executed on the field, namely 30, 45, and 60 degrees. Students also began to understand the sides of a right-angled triangle, making it easier for them to draw patterns based on the illustrations presented in the story. In Figure 5 below, students began calculating the distance of the player's kick using the triangle pattern presented in the fifth meeting.

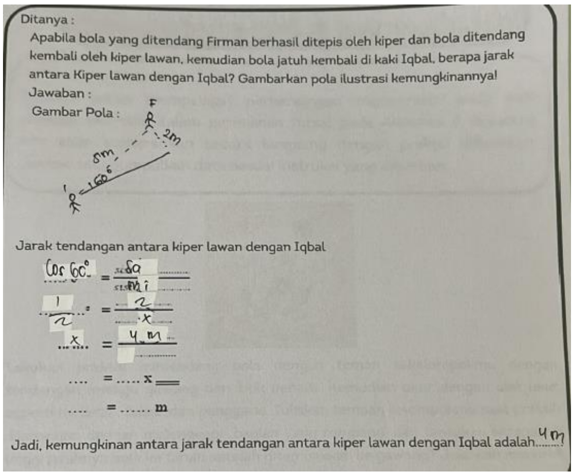


Figure 5. Results of the LKPD answers for the fifth meeting group

In Figure 5, the fifth meeting, the students in groups appeared to have mastered the material from the first to the fifth meeting. They provided the expected answers by using the known side lengths to determine the lengths of the other sides, in this case, the distance between the opposing goalkeeper and one of the Indonesian futsal players. The preparation of the LKPD with structured answers had a positive impact on the students [36]. Most of them can remember the steps to answer the posttest at the end of the session, which no longer provides blank spaces to fill in.

Meanwhile, in the sixth meeting, students were asked to analyze story problems in which the pattern formed in the field was not a right triangle but a random triangle. In this case, students gained new knowledge that trigonometry in the context of futsal, specifically the ratio of right triangles, can also be used to solve arbitrary triangles by applying the cosine law formula. Contextual, interactive, and student-centered learning, such as this, provides innovation with an active classroom atmosphere and students feeling the difference from the previous learning system [37].

The contextual mathematical approach (RME) applied with the PBL model not only improves students' creative thinking skills but also adds a new dimension to mathematics learning by providing space for students to express their knowledge creatively and critically, increasing their curiosity and actively participating in the learning process [38]. Learning successfully can be accomplished if the learning material is well absorbed by students [39].

Based on the discussion above, it can be seen that students' creative thinking skills improved with the application of trigonometry learning in the context of futsal. In line with previous studies, students who used the RME approach were found to be more active and to have a better understanding of mathematical concepts than those who used direct instruction [40]. In addition, learning futsal in context motivates students to learn and solve math problems in a familiar context. The results of this study reinforce the evidence that mathematics instruction with the context of futsal, among other sports, can develop students' creative thinking abilities and show that context-based sports instruction provides a meaningful bridge between abstract mathematical concepts and real-life applications, particularly in the field of sports.

4. CONCLUSION

The overall results of the study indicate that the hypothesis can be accepted, namely that there is a difference between before and after the implementation of trigonometry learning in a futsal context within the trigonometry material. Findings indicate that using real-life contexts relevant to students encourages them to be more active and creative in solving math problems. There was an increase in the average pretest-to-posttest score. The Wilcoxon test showed a significant difference between the before and after measurements. In addition, the N-Gain test in the high category was interpreted as effective. Learning conducted in the context of futsal, by maximizing achievement of learning objectives across several meetings, gave the impression of meaningful and enjoyable learning for students. Thus, it can be concluded that trigonometry learning in the context of futsal is effective and shows a significant difference between pre- and post-treatment in measuring students' creative thinking abilities.

This study implies that mathematics teachers can apply sports contexts as a new and meaningful learning strategy for students. However, this study has limitations, namely the absence of a control group for comparison and a limited sample size; therefore, the findings must be interpreted with caution. Therefore, future research is recommended to use a more complex experimental design, explore other contexts, and apply it at other levels of mathematics education. This study is also expected to contribute to the 2030 SDGs on quality education by developing innovative, creative, and relevant mathematics learning that aligns with students' daily lives.

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