iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** XII **Month of publication:** December 2025

DOI: https://doi.org/10.22214/ijraset.2025.76209

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XII Dec 2025- Available at www.ijraset.com

Enhancing First Year Geodetic Engineering Students' Unit Conversion Skills through Board Games

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Abstract: ***This study explored the use of a board game based learning approach to help improve the unit conversion skills of first year Geodetic Engineering students at Batangas State University. Unit conversion is a basic skill in science and engineering which students tend to have trouble with in practice. We aimed to see what the board game intervention did for the students' performance in terms of accuracy, speed, and what they thought of the difficulty progression. This research, framed under the learning interaction and engagement model initially used to describe the experience of first-year Geodetic Engineering students in synchronous modalities, investigates the enhancement of unit conversion skills of students using a board game-based learning approach. Sixteen participants undertook a unit conversion test and a validated Likert-scale survey to determine improvements in accuracy, speed, and difficulty, and perceived efficacy and engagement. There was strong agreement that the board game improved accuracy, WM = 3.43; speed, WM = 3.56; and ability to manage difficulty, WM = 3.46. The pre-test score showed low initial mastery, while the post-test score significantly increased, with all students getting a score of 8 and above and more than half getting a perfect score, supported by a highly significant t-value, t = 10.03, p = 0.00000018. Students also strongly agreed that the board game was effective, WM = 3.65, and engaging, WM = 3.73. The results indicated that board game-based learning is an effective and motivating strategy for improving the unit conversion skill in Geodetic Engineering education.***
Keywords: board game-based learning, unit conversion skills, learning intervention, accuracy and speed, difficulty progression, educational board game, student performance, quantitative research, quantitative research.

I. INTRODUCTION

Unit conversion is a mathematical skill that involves converting from one unit to another. However, it is not only exclusive to mathematical equations but also in the field of science. With science, specifically in chemistry, unit conversion can be used in determining speed (m/s), pressure (P), volume (V), moles (mol), temperature (°C/°F/K), etc. According to the study of Raje (2019), the concept of unit conversions serves as a bridge between mathematics and science as both tackle unit measurement and conversion through scientific literacy and mathematical numeracy.

In the study of Brignac (2020), the concept of unit measurement and conversion is a fundamental skill that is taught in high school, which leads to college students being expected to know the basics of units. However, students often struggle when units are used and applied to real-life problems.

Teachers and professors help students to relearn fundamental knowledge about units and engage with higher difficulties to expand and test the students' skills in converting units. Based on Tadie, et al. (2018), educators ensure that the whole curriculum is taught to students, gaining knowledge about the concepts of units, measurements, and conversions.

Board games are an example of a learning strategy that enhances the students' understanding capabilities of the lesson, providing engagement, critical thinking, teamwork and communication through group-based learning. According to the study of Garcia-Ramirez (2025), through the board game-based learning strategy, students are more engaged in playing in groups, resulting in significant improvements in strategy, comprehension, and communication with their respective groups.

Therefore, to enhance the unit conversion skills of students, we have to consider the knowledge of students about units, the level of comprehension, and the engagement towards board games as a learning strategy. These are important key points to assess the effectiveness of enhancing the students' unit conversion skills through board games. Thus, the researchers conducted a study in enhancing students' unit conversion skills through board games.

II. OBJECTIVES

This study aims to enhance the unit conversion skills of first-year geodetic engineering students through a board game-based learning approach.

Specifically, this study seeks to answer the following questions:

1) Determine the unit conversion skills of geodetic engineering students using board game-based learning in terms of:
- Accuracy
- Speed
- Difficulty

2) Assess the use of board game-based learning in enhancing the unit conversion skills of Geodetic Engineering students through pre-test and post-test.

3) Explore the extent of board games as a learning tool for unit conversion method in terms of:
- Efficacy
- Engagement

III. MATERIALS AND METHODS

A. *Research Design*

This study will employ quantitative research design to assess the effect of using board games on first year geodetic engineering students' unit conversion skills. The quantitative component will assess the students' unit conversion performance in terms of accuracy, speed, and difficulty by gathering numerical data through pre-test before playing the board game, and post-tests at the end of the game. This method corresponds with Hwang et al. (2019), who state that quantitative pre-test and post-test designs effectively measure learning gains in game-based environments. Additionally, survey questionnaires will be distributed to evaluate the efficacy of the board game and the engagement of the participants which is a viewpoint supported by Kim (2018) who considers questionnaires as reliable tools for evaluating the responses of learners in the domain of quantitative educational research. This approach enables researchers to assess the outcome, providing a clear understanding of the impact of board games to the students' unit conversion skills..

B. *Subjects of the Study*

The research data is gathered at Batangas State University– Alangilan Campus, the study was conducted inside the campus premises for the safety and convenience of the participants and implemented within 2 days. The target respondents of the study are 16 first-year Geodetic Engineering students consisting of 4 groups with 4 members each selected through simple random sampling to provide every member of the population an equal opportunity of being included in the study. The first 2 groups were selected first to play the board game for the game to be smoothly conducted without factors that could affect it like being too crowded that can lead to multiple noise and misunderstandings. And then, the remaining 2 groups played the next day. They were divided by using spin-the-wheel wherein the first 2 groups were chosen to play first.

Table 1. Distribution of Respondents

First Year Geodetic Engineering Students	Population of Students
Batangas State University- Alangilan	16
Total	16

C. *Data Gathering Instrument*

A questionnaire made by the researcher was the main way that information was gathered for this study.

Questionnaire. This study utilized a own-made unit conversion test and a structured survey questionnaire.The unit conversion test was given to students as pre and post-tests, which helped to assess their level of proficiency before and after the board-game intervention. It consisted of ten items, with the first five items multiple-choice worth one point each and the remaining five as problem-solution questions with the last three worth three points. The test was reviewed and validated by the researchers ensuring that the content is also similar to the questions given out during the board game activity.

Scoring of Responses. A 25-item Likert-scale survey questionnaire was also employed to gather quantitative data on students' performance, engagement, and perceptions of the board-game learning. The questionnaire consisted of ten items that evaluated the students' performance in terms of accuracy, speed and difficulty, five items that assessed students' engagement during playing the game, and ten items that measured the perceived effectiveness of the intervention. The questionnaire was validated by the research adviser to ensure relevance, coherence, and alignment with the study's variables.

Option	Scale Range	Adjectival Rating
4	*3.21-4.00*	Strongly Agree
3	*2.52-3.20*	Agree
2	*1.76-2.50*	Disagree
1	*1.00-1.75*	Strongly Disagree

D. Data Gathering Procedure

Prior to data gathering, informed consent was obtained from all participants to ensure ethical compliance, voluntary participation, and confidentiality. The data collection process began with a brief explanation from the researchers regarding the procedures for both groups. First, participants completed a 30-minute pre-test to assess their baseline unit conversion skills. After the pre-test, the groups were gathered for the board game activity. The researchers explained the mechanics of the game, which uses three color-coded boxes (green, yellow, and red) representing Easy, Medium, and Hard difficulties. Each difficulty has a corresponding time limit and point value: Easy allows 10 seconds for 3 points, Medium allows 30 seconds for 5 points, and Hard allows 1 minute for 10 points. These levels also differ in player involvement, with Easy requiring one player, Medium involving two players with a calculator, and Hard allowing three players with a calculator. Players must answer the conversion problem within the allotted time, and exceeding the limit results in an incorrect answer. Certain cards also include power-ups such as the ×2 multiplier, the 4-in-1 teamwork card, the Calculator card, and the Block card, all of which add strategic elements to the game. The winning condition requires a group to reach 100 points. During gameplay, each researcher was assigned a specific role such as recording scores, handling the timer, managing the game flow, and monitoring fairness. The board game session lasted for approximately one hour. Immediately after the activity, a 30-minute post-test was administered to determine any improvement in the participants' knowledge and skills in unit conversion. Finally, the researchers distributed a Google Form survey-questionnaire, which gathered quantitative data on several variables: accuracy, speed, difficulty progression, the perceived effectiveness of the board game, and participant engagement. This ensured a comprehensive assessment of the board game's impact on the students' unit conversion skills.

IV. RESULTS AND DISCUSSION

A. Unit Conversion Skills of Geodetic Engineering Students using Board Game-Based Learning in terms of Accuracy, Speed, and Difficulty.

1) Accuracy

Table 2. Students' Assessment in Accuracy of the Board Game

Indicators	WM	VI
1.The board game helped me answer unit conversion problems more accurately.	3.69	Strongly Agree
2. My mistakes in unit conversion decreased after using the board game.	3.25	Strongly Agree
3. The activity improved my precision when solving conversion tasks.	3.63	Strongly Agree
4. I feel more confident that my unit conversion answers are accurate.	3.44	Strongly Agree
5. I can accurately convert units across different measurement systems (length, mass, time, etc.) after using the board game.	3.13	Agree
Overall	3.43	Strongly Agree

Table 2 shows the students' assessment in the board game which results in an average score of 3.43, which signifies that the respondents strongly agree with the result of their performance when using the board game. This aligns with the interpretation of the overall assessment in the board game, as an alternative learning method for unit conversion. According to the study of Xu and Lenton (2017), where described approaches such as handling fractions and other learning methods, improves the overall accuracy of the student through unit conversion.

2) Speed

Table 3. *Students' Assessment in Speed of the Board Game*

Indicators	WM	VI
1. I can now convert units faster after the board game activity.	3.69	Strongly Agree
2. The board game increased my confidence in answering problems quickly.	3.63	Strongly Agree
3. I was able to finish conversion tasks faster compared to before.	3.69	Strongly Agree
4. The repetitive practice from the board game increased my conversion speed.	3.5	Strongly Agree
5. The time pressure element in the board game improved my ability to work quickly under pressure.	3.31	Strongly Agree
Overall	**3.56**	Strongly Agre

In the table above, it shows the evaluation of the respondents based on how fast the respondents are when it comes to converting units. The high rating reflects on how the board game affects one's speed in unit conversion. Most of the answers are leaning on the conclusion that the board game mechanic helped them convert units over time pressure. Resulting to 3.56 as the mean/average of the interpretation of the table, where the students strongly agree towards their overall speed when performing unit conversion through the board game.

3) Difficulty

Table 4. Students' Assessment in Difficulty of the Board Game

Indicators	WM	VI
1. The board game made unit conversion tasks feel easier to understand.	3.34	Strongly Agree
2. The board game reduced the difficulty I usually experience with conversions.	3.19	Agree
3. The steps for solving conversions became clearer after the activity.	3.63	Strongly Agree
4. The board game made difficult unit conversion lessons easier to understand.	3.63	Strongly Agree
5. I am now more willing to persist through challenging conversion problems rather than giving up.	3.5	Strongly Agree
Overall	**3.46**	Strongly Agre

In the study of Dincer and Osmanoglu (2018), they administered a set of questions where they examined their skill towards difficulties involving unit conversions. The results conveyed that the prospects' performance on unit conversion declines when conducting unit conversions between measures of difficulty. The different levels of difficulty affects the performance of the respondents in converting units. This leads to having an average of 3.46, proving that the students respond and strongly agree about their capability to solve various unit conversion difficulties. The table suggests that the analysis of the respondents' display positive results towards unit conversion with the use of the board game.

B. The Use of Board Game-Based Learning in Enhancing the Unit Conversion Skills of Geodetic Engineering Students through Pre-Test and Post-Test.

Table 5. Pre-Test Score Result

Score	Frequency	Percentage
10	0	0
9	2	12.5%
8	2	12.5%
7	0	0
6	2	12.5%
5	3	18.75%
4	1	6.25%
3	4	25%
2	1	6.25%
1	1	6.25%
0	0	0
Total	16	100%

The Pre-Test scores of the Geodetic Engineering students regarding their Unit Conversion Skills, as shown in Table 5, reveal a foundational weakness in the subject prior to the board game intervention. With a total of 16 students, the majority of the scores clustered in the lower half of the 10-point scale, with 62.5% of the class (10 students) scoring 5 or below. The most frequent single score was 3, accounting for 25% of the responses, indicating that a significant portion of the students possessed inadequate mastery of the skill. While a small number of students (4) showed higher competency, scoring 8 or 9 (25%). While testing is often exclusively associated with summative assessment, serving to measure whether or not students have achieved desired learning outcomes after a unit of instruction, the utilization of the pre-test here is fundamentally formative and diagnostic (Janelli & Lipnevich, 2021). The low pre-test results, particularly the concentration of scores at 5 and below, align with the literature by providing the essential evidence of a knowledge deficit that validates the need for a non-traditional pedagogical approach. By clearly establishing the students' initial poor mastery, the pre-test serves a critical dual function: it informs the researcher that the intervention is justified, and it confirms the students' low starting point, thus setting the stage for a scientifically meaningful comparison with the expected gains in the post-test.

Table 6. Post-Test Score Result

Score	Frequency	Percentage
10	9	56.25%
9	5	31.25%
8	2	12.5%
7	0	0
6	0	0
5	0	0
4	0	0
3	0	0
2	0	0
1	0	0
0	0	0
Total	16	100%

The post-test scores documented in Table 6 show a large and definitive increase in the Unit Conversion Skills after the intervention. The comparison to the pre-test is very clear and positive; the post-test data indicates that all the students scored 8 or above. The scores were also heavily centered on the top of the scale, where 56.25% of the students got a full score of 10.

The significant transition from the low pre-test starting point to the high post-test scores not only justifies but also serves the purpose of a post-intervention assessment. Shivaraju et al. (2021) pointed out that a post-test is a measure of the students' receptive power as well as the teaching effectiveness. The data confirms the depicted high teaching effectiveness, which in turn, points out that the board game has been successful in making the learning process quite deep.

Table 7. Significant Difference between Pre-Test and Post-Test Scores

Test	Mean	SD	t-value	p-value	Remarks
Pre-Test	5.00	2.50	10.03	0.00000018	Significant
Post-Test	9.44	0.73			

Table 7 illustrates the outcomes of the t-test performed by means of inferential statistics on the pre-test and post-test scores. The figures indicate a considerable numerical difference in the performance, as the pre-test mean was present at 5.00 while the post-test one rose significantly up to 9.44. The potency of the intervention is proved by this large mean difference of 4.44. Furthermore, the Standard Deviation (SD) plummeted dramatically from 2.50 to 0.73. This drop signifies that the scores of the students were not only high but also close to one another, thereby indicating a greater degree of uniformity and reliability in their mastery. The generated t-value is 10.03, which leads to an extremely tiny p-value of 0.00000018. This outcome aligns with related studies, such as that by Arpilleda (2021), which concluded that strategic intervention materials gave a positive impact in mastering identified competencies.

Table 8. Students' Learning Gains during Pre-test and Post-test

Indicators	WM	VI
1. The skills practiced in the board game were directly applicable to the assessment questions.	3.5	Strongly Agree
2. My post-test score showed improvement after using the board game.	3.69	Strongly Agree
3. The board game contributed significantly to my learning progress.	3.81	Strongly Agree
4. The activity helped me retain concepts better between the pre-test and post-test.	3.56	Strongly Agree
5. I found the post-test questions more manageable after practicing with the board game.	3.94	Strongly Agree
Overall	3.7	Strongly Agree

The students' self-assessment, as summarized in Table 8, shows a mean of 3.7, which equals a consistent 'strongly agree' interpretation across all indicators regarding the board game's contribution to their learning. The highest mean score (3.94) was recorded for Item 5: "I found the post-test questions more manageable after practicing with the board game,". This high score indicates that the intervention effectively boosted students' perceived competency and reduced assessment-related anxiety by making the subsequent test feel more accessible.

The game activity was, thus, regarded as playing an important role in the learning process (Item 3, Mean 3.81) and in maintaining better understanding of the concepts (Item 4, Mean 3.56). This supports the idea that continuous evaluation, characteristic of formative assessment, encourages student engagement and critical thinking while promoting reflective teaching practices. This outcome therefore, is in line with the work by Sirianansopa (2024), who emphasizes the value of instructional feedback in refining teaching strategies and promoting effective learning practices.

C. The Extent of Board Games as a Learning Tool for Unit Conversion Method in Efficacy and Engagement.

1) Efficacy

Table 9. Students' Assessment in Efficacy of the Board Game

Indicators	WM	VI
1. The board game effectively taught me the steps of unit conversion.	3.38	Strongly Agree
2. The mechanics of the game supported my understanding of conversion formulas.	3.69	Strongly Agree
3. The board game is an effective tool for reinforcing lessons in unit conversion.	3.69	Strongly Agree
4. The board games captured my interest better than traditional learning methods.	3.69	Strongly Agree
5. I would highly recommend the use of this board game to future students struggling with unit conversion.	3.81	Strongly Agree
Overall	3.65	Strongly Agree

Table 9 shows the student's assessment of the efficacy of the board game. The overall mean is 3.65, interpreted as Strongly Agree. This supports the study of Chen et al. (2021), who assessed that after implementing board games for learning chemistry, the students' scientific concept and problem solving skills improved. It shows that using board games as learning material has a high success and effectiveness in enhancing the unit conversion skills of the first year geodetic students.

2) Engagement

Table 10. *Students' Assessment in Engagement of the Board Game*

Indicators	WM	VI
1. The board game increased my interest in learning unit conversion.	3.63	Strongly Agree
2. I was more engaged and active during the board game activity.	3.75	Strongly Agree
3. The game made the learning experience enjoyable and motivating.	3.81	Strongly Agree
4. The use of board games made learning unit conversion more enjoyable and engaging.	3.81	Strongly Agree
5. The interactive style of the board games encouraged collaboration and teamwork among students.	3.63	Strongly Agree
Overall	3.73	Strongly Agree

The table 10 shows the students' assessment in engagement of the board game. This results in an average score of 3.73, it shows that the students strongly agree that the board game learning is engaging. According to Cardinot & Fairfield (2019), game based learning could motivate and engage students, also it helped the students to have active participation and interaction while learning. This results that the board game based learning helped the students collaborate and enjoy the unit conversion while playing.

V. CONCLUSIONS

In connection with the findings of the study, the following conclusions were drawn:

1) The responses on accuracy, speed, and difficulty resulted in high levels of agreement that the board game developed the performance of the students. The overall means of 3.43 in terms of accuracy, 3.56 in terms of speed, and 3.46 in terms of difficulty all fell within the Strongly Agree range, thus inferring that the gamified approach not only reinforced their computational skills but also made difficult concepts more manageable.

2) The comparison of pre-test and post-test scores validated the effectiveness of the intervention. The pre-test results indicated a weak baseline understanding, with most students scoring below the middle point of the test. The increase in mean score from 5.00 to 9.44 is indicative of strong learning gains across the group. The t-test results confirmed that a statistically significant difference was found between the pre-test and post-test scores ($p = 0.00000018$), affirming that the board game intervention was highly effective in enhancing mastery of unit conversion skills.

3) Students strongly agreed about the efficacy and engagement of the board game, with means of 3.65 and 3.73, respectively. These values signify that the board game is not only effective as a learning tool but also as an instructional method for generating interest, motivation, and active participation. The results confirm that board game-based learning is a strong alternative instructional approach to teaching unit conversion, effectively enhancing students' accuracy, speed, and ability in handling varying levels of difficulty while improving engagement and motivation.

VI. RECOMMENDATIONS

In light of the findings and conclusions of the study, the following recommendations are hereby presented:

1) Further improvisation of the game and its mechanics is needed for better elaboration and understanding of the game.

2) Evaluation of the game proper would be assessed to ensure stability and smoothness of gameplay. To bring fairness and capability to the players for the betterment of the full utility of the board game.

3) Integrating similar game-based approaches within mathematics and engineering-related subjects to enhance the foundational skills of students and to promote deeper and more meaningful learning experiences.

VII. ACKNOWLEDGEMENT

The researchers of the study would like to show their heartfelt and genuine gratitude and express recognition to the following people who whom contributed to the paper's success:

To their respective Chemistry Professor, Sir Bryle A. Armeza, for his unwavering and exceptional guidance all throughout the process of making the papers. In addition, his incredible teaching methods hugely assist the researchers in the process of achieving the paper's success.

To the Researcher's Parents, with their non-stop support and ineffable care towards their children experiment; thus, manifesting a huge success to the research paper's process and their children too.

Above all, to the Almighty God, for His guidance and continuous love to the researchers. With his wisdom and omnipresence, it provides the researchers care, strength, resilience, and keen insights.

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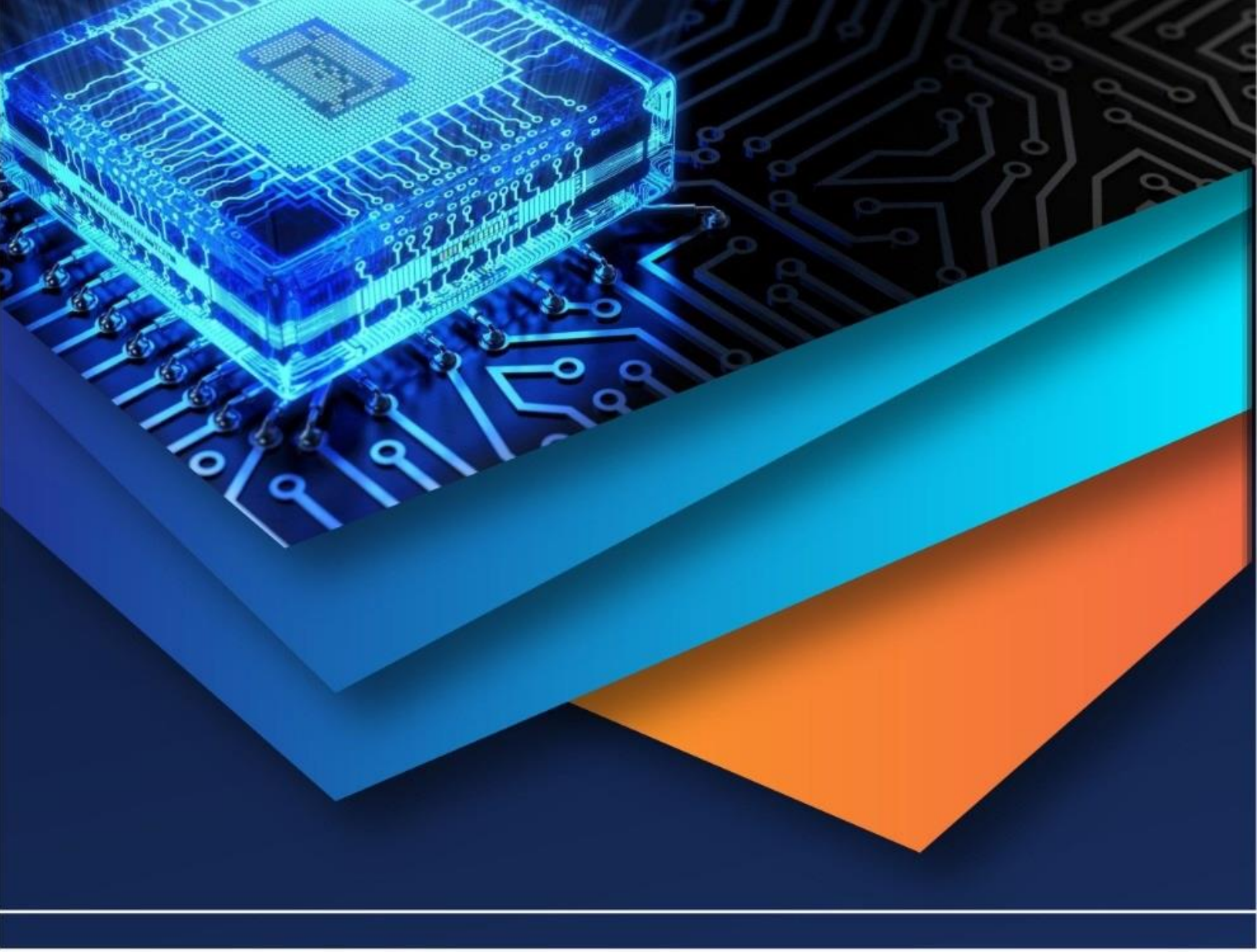

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