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Enhancing Chemical Bonding Comprehension through Visual AIDS Among First Year Geodetic Engineering Students

Annie Jane M. Dimaano[1], Lee Hazel O. Fajilan[2], Alfonso Miguel V. Vesliño[3], Joanne Marielle M. Gojo Cruz[4], Johnrolf Marico R. Majait[5], Paula F. Pacyaan[6], John Eros I. Villareal[7], Bryle A. Armeza[8]
Bachelor of Sciences in Geodetic Engineering, Batangas State University, The National Engineering University, Batangas City, Philippines

Abstract: ***This research aims to enhance chemical bonding comprehension through visual aids among first-year Geodetic Engineering students at Batangas State University. Abstract concepts of chemistry, like ionic, covalent, and metallic bonding, are difficult to master for many students; hence, the need to try out instructional tools that will enhance understanding among learners. This research uses a quantitative-descriptive research design. The researchers prepared a survey questionnaire with validated questions and administered it to 50 students coming from Geodetic Engineering 1101 and Geodetic Engineering 1102. Three areas were measured by the study: difficulties of students learning chemical bonding, assessment of visual aid videos on explanation, usefulness, and engagement, and an overall effectiveness of these visual aids. Results showed that the students strongly agreed that the video visual aids had supported their learning immensely, improved retention, clarified several complex ideas, and bridged many gaps. It was noted that especially, visual explanations enhanced the connection between classroom instruction and independent learning. These results show that the use of visual aids is a very effective instructional tool to simplify abstract chemistry concepts and thereby enhance students' comprehension. This study recommends the further use of appropriately designed visual materials in every lesson in chemistry to enhance deeper understanding of concepts.***
Keywords: Chemical bonding, Geodetic Engineers, Visual Aids and Learning Comprehension.

I. INTRODUCTION

One of the core subjects in engineering is chemistry, it forms the basis of learning about materials, reactions, and processes relevant to the field. Chemistry is usually regarded as a challenging subject, as most of its concepts differ from the daily life experiences of the students. The students often form misunderstandings that make it hard to understand chemical concepts clearly (Treagust et al., 2018). Many students struggle to understand some chemical concepts, including chemical bonding, because it is abstract and cannot be visualized easily. It particularly affects the first-year geodetic engineering students, which leads to poor comprehension.

Chemical bonding is one of the basic concepts in chemistry that describes the combining of atoms to produce stable molecules and compounds. It results from many types of interactions that cause the stabilization of atomic systems. Of the many types of bonds, covalent bonding is the most important, as it is characterized by the sharing of electron pairs between atoms for stability. The organization and conduct of electrons, as dictated by concepts like the Pauli Exclusion Principle, contribute significantly to how strong and organized these bonds are. Understanding chemical bonding is essential because it explains the composition, properties, and chemical reactions of different compounds, which are important in the study of chemistry and its applications in engineering sciences (Abedi, 2022). In addition, understanding chemical bonding enables learners to relate theoretical understanding to practical uses, including the creation of materials and chemical reactions in engineering applications. Since atomic interactions are often abstract, visual aids can help the students understand the concept more. To help students learn complex topics like chemical bonding easily, the use of visual aids is one of the effective teaching strategies. According to Alabi (2024), visual aids are an essential tool for learning by applying images, diagrams, charts, and videos to enhance understanding and knowledge recall. Visual aids help learners with complicated concepts and identifying patterns that are hard to understand from text or lectures only. Visual aids are helpful particularly in sciences and mathematics, where they bring abstract or non-visible lectures into a more tangible and comprehensible form. Visual aid materials enhance memory and interest like infographics, flowcharts, and multimedia presentations. They also promote active learning by making students see relationships and processes in clear images. The integration of visual aids in education enhances learning to be more effective, inclusive, and engaging for different learners.

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Difficulties in understanding the concept of chemical bonding are still experienced by first-year geodetic engineering students in Batangas State University. With the continuous use of traditional teaching methods such as lectures and textbook-based discussion of the said topic, its abstractness makes it difficult for students to see how atoms interact and combine into compounds; confusion and misconception arise from this.

Therefore, the goal of this study is to determine the effectiveness of visual aids in enhancing students' understanding of chemical bonding for first-year geodetic engineering students. This research aims to establish the learning challenges faced by students when learning chemical bonding and to examine how visual aids can assist in overcoming such challenges. With the use of visual learning aids like videos, diagrams, and models, this study aims to make abstract concepts clearer. The findings of this study will give insights into how visual aids can be effectively used in chemistry to improve students' comprehension of chemical bonding.

II. OBJECTIVES OF THE STUDY

This study aims to determine the effectiveness of visual aids in enhancing the understanding of chemical bonding among first-year Geodetic Engineering students. Specifically, it seeks to achieve the following objectives:

1) Identify the difficulties encountered by students in learning chemical bonding.
2) Determine the effectiveness of visual aids in enhancing students' understanding in chemical bonding in terms of explanation, usefulness and engagement.
3) Evaluate the improvement in students' understanding after using visual aids.

III. MATERIALS AND METHODS

A. Research Design

In this study, the researchers consider the quantitative research method to be used to lessen the bias and give accurate and objective results. Quantitative research is used in this research since it allows the researchers to collect measurable and objective information on enhancing chemical bonding comprehension through visual aids. This method makes it easy to verify the findings, increasing the credibility of the study (Mahardini et al. 2024). Descriptive research design is used since it enables the collection of data that highlights patterns and data in the subject being studied. It is used to systematically gather and analyze data as for the students' understanding of chemical bonding. It helps evaluate the effectiveness of visual aids in terms of their explanation, usefulness, and engagement, through the use of a structured questionnaire and a four-point Likert scale to obtain objective and measurable results. This approach allows the researchers to identify common learning problems, evaluate how visual aids enhance comprehension, and provide recommendations for enhancing teaching methods (Heath, 2023).

B. Subjects Of The Study

This study used first year BSGE students from the Alanginan campus of Batangas State University as respondents. Geodetic Engineering students are reliable sources of data because they directly study chemical bonding in their foundational courses, making them well-positioned to offer opinions regarding how effective the use of visual aids is in understanding the chemical bonding concepts. The distribution of respondents per campus is presented in table 1.

Table 1. Distribution of Respondents

Geodetic Engineering Students	Population of Students
BS GEODENG 1101	25
BS GEODENG 1102	25
Total	50

C. Data Gathering Instrument

This study will use survey questionnaires as a research instrument. According to McLeod (2023), a questionnaire is a research instrument made up of a set of questions aimed at gathering data from respondents. It facilitates data collection on a variety of subjects and makes it easier to analyze and evaluate the information acquired.

The questionnaire is divided into three parts based on the statement of the problem.

The first part aims to identify the difficulties encountered by the students regarding the learning of chemical bonding, pointing to which topics and concepts are difficult for the students to understand. The second part of the questionnaire is designed to assess the visual aid video in terms of explanation, usefulness, and engagement, and how effective these are in supporting learning. The third part focuses on determining the effectiveness of visual aids in enhancing the comprehension of chemical bonding among first-year Geodetic Engineering students. This organized method guarantees an in-depth review of enhancing chemical bonding comprehension through visual aids.

Rating Scale	Interpretation
3.21 – 4.00	Strongly Agree
2.52 – 3.20	Agree
1.76 – 2.50	Disagree
1.00 – 1.75	Strongly Disagree

D. Data Gathering Procedure

The researchers first finalized the statement of the problem and had it approved by the chemistry professor. After the approval, the researchers then proceed to construct the questionnaires. The survey questionnaires were intended to measure variables such as the visual aids, students' understanding of chemical bonding, and the difficulties encountered by students. The assessment of the visual aids in terms of explanation, usefulness, and engagement was also added.

Data gathering for this research started with the validation of the questionnaire to ensure its reliability and relevance. The researchers submitted the constructed questionnaire to the chemistry professor for approval. After the approval, the questionnaire was validated to ensure that questions captured all the important details. The questionnaire was refined based on professors' feedback to ensure that they were objective, clear, and could obtain relevant information. The effectiveness and accuracy of the questionnaire were ensured through this rigorous validation process before it was administered to the participants.

After validating the questionnaires and finalizing the visual aid, a structured questionnaire was distributed to the selected respondents and were given online. The respective respondents answered the survey questionnaires, in which they provided the necessary information regarding the effectiveness of enhancing chemical bonding comprehension through visual aids. The respondents were given plenty of time to answer the questionnaires to obtain valid and reliable data. The researchers ensured the confidentiality of the data coming from the respondents, and it will only be used for research purposes and will be kept until the relevance of the study is no longer needed.

IV. RESULTS AND DISCUSSION

A. Difficulties Encountered by Students in Learning Chemical Bonding

The difficulties encountered by Geodetic Engineering students' in Learning Chemical Bonding.

Table 2. Difficulties Encountered by Students in Learning Chemical Bonding

INDICATORS	MEAN	INTERPRETATION
I cannot easily distinguish between ionic, covalent, and metallic bonds when taught only by lecture.	4.06	Strongly Agree
I have trouble visualizing how electrons are shared or transferred between atoms, especially without diagrams or animations.	4.26	Strongly Agree
I get confused with the symbols and notations used in chemical bonding.	4.34	Strongly Agree

I struggle to understand how the type of elements involved affects the kind of bond that forms.	4.12	Strongly Agree
I find it hard to connect different concepts related to chemical bonding into one clear idea.	4.10	Strongly Agree
I struggle to explain chemical bonding concepts in my own words.	4.10	Strongly Agree
I find it challenging to apply bonding concepts to real-life situations or Examples	4.14	Strongly Agree
I have difficulty comparing the behavior of electrons across different types of bonds.	4.12	Strongly Agree
I get confused how the strength and properties of ionic, covalent, and metallic bonds differ from one another.	4.14	Strongly Agree
I have difficulty summarizing the differences and similarities between bond types.	4.06	Strongly Agree
OVERALL	4.14	Strongly Agree

This section presents the findings on the difficulties encountered by students in learning chemical bonding. Responses were collected using a Likert scale–based survey, where students indicated the extent to which they agreed with statements describing common challenges related to understanding ionic, covalent, and metallic bonding, as well as associated symbols, notations, and conceptual applications.

The data in Table 1 illustrate that students strongly agree that they encounter various difficulties in learning chemical bonding, as indicated by the composite mean of 4.14. The highest rated statement, “I get confused with the symbols and notations used in chemical bonding” (WM = 4.34), suggests that symbolic representations pose the greatest challenge for learners and significantly affect their understanding of bonding concepts. This aligns with the findings of Dawati et al. (2019), students consistently showed the most difficulty with symbolic levels of chemical bonding, such as molecular formula, chemical notations, and translation between levels (microscopic, submicroscopic, and macroscopic).

Meanwhile, the lowest rated items, both with a weighted mean of 4.06, indicate that students still strongly agree but to a lesser degree that they struggle to distinguish between types of bonds and to summarize their similarities and differences. This implies that while these areas are still difficult, they are relatively less problematic compared to other aspects of chemical bonding. This supports the work of Widarti (2018), the abstract nature of most chemical concepts makes them impossible to directly visualize.

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Since students cannot see these processes, they often interpret chemical phenomena in different ways, leading to confusion and misconceptions, which can make it difficult to distinguish and summarize different types of bonds.

B. Analyzation of visual aids in enhancing students' understanding in chemical bonding

Analyzation of visual aids in enhancing students' understanding in chemical bonding in terms of explanation, usefulness and engagement.

1) Explanation

Table 3. Analyzation of Visual Aid Videos in terms of Explanation

INDICATORS	MEAN	INTERPRETATION
The language used in the videos is appropriate for my level of understanding.	4.32	StronglyAgree
The information presented in the videos is scientifically accurate and reliable.	4.44	StronglyAgree
The videos explain chemical bonding concepts in a clear and simple manner.	4.44	StronglyAgree
The explanations in the videos connect well with what is taught in class.	4.48	Strongly Agree
The examples in the videos help me understand the topic better.	4.42	Strongly Agree
OVERALL	4.42	Strongly Agree

The results in table 2.1 indicate that students strongly agree that the explanations provided in the visual aid videos effectively support their understanding of chemical bonding, as reflected in the composite mean of 4.48. The most favored statement, “The explanations in the videos connect well with what is taught in class” (WM = 4.48), suggests that the videos successfully reinforce classroom instruction and provide coherent explanations linking to the curriculum. This corresponds with the results of the Wasito (2020), the use of visual media in education increases the interaction and engagement for students in the classroom and thus enhances their motivation in class. The use of visual aids supports better communication among educators and students and therefore provides a clear understanding for the students regarding the lesson and concepts studied.

Items rated in the middle range, specifically the scientific accuracy of the information and the clarity of chemical bonding explanations (both WM = 4.44), further indicate that students perceive the videos as reliable and easy to comprehend. This parallels the findings of Okoye et al. (2025), students exposed to animated visual content on chemical bonding showed a significant improvement in understanding and performance compared to the traditionally instructed ones. Proper and clear visualizations of complex chemistry concepts allow for easy comprehension and retention.

The lowest mean score of 4.34, related to the appropriateness of the language used in the videos, while still strongly agreed upon, points to a minor area for potential enhancement in tailoring language to learners’ needs. This strengthens the conclusions of Malakul & Park (2023), a significant improvement in comprehension and reduced cognitive load while providing subtitles to the learners, especially for cases where the language of narration was different from their first language. Even very effective visual learning aids can be constrained by language appropriateness alone, and adjustments of vocabulary or phrasing or adding subtitle support can further enhance learning outcomes.

Overall, these findings demonstrate a consistent and strong positive attitude toward the explanatory quality of the visual aid videos, confirming their effectiveness as a learning tool.

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2) Usefulness

Table 4. Analyzation of Visual Aid Videos in terms of Usefulness

INDICATORS	MEAN	INTERPRETATION
The visual aid videos help me remember the lessons better.	4.44	Strongly Agree
The videos make the topic of chemical bonding easier to understand.	4.34	Strongly Agree
The videos make reviewing chemical bonding lessons more convenient.	4.42	Strongly Agree
The videos help bridge gaps in my understanding of chemistry topics.	4.36	Strongly Agree
I can apply what I learned from the videos to solve related problems.	4.36	Strongly Agree
OVERALL	4.40	Strongly Agree

The outcomes presented in Table 2.2 reveal that students strongly agree that the visual aid videos are useful in enhancing their learning of chemical bonding, as reflected in the composite mean of 4.40. The statement with the highest mark, “The visual aid videos help me remember the lessons better” (WM = 4.44), suggests that the videos significantly contribute to improving students’ retention of the lesson content. This result corresponds with the findings of the study of Regondola and Astorga's (2025) study indicates that visual learning material would be more beneficial in such cases since it would assist students remember past lessons, making it simpler to understand new concepts while improving overall comprehension. When considering information in the context of chemical bonding, it appears that visual aids such as molecular diagrams, animations, and models can make the topic more understandable and interesting for students.

Items with moderate mean scores, such as “The videos make reviewing chemical bonding lessons more convenient” (WM = 4.42), “The videos help bridge gaps in my understanding of chemistry topics” (WM = 4.36), and “I can apply what I learned from the videos to solve related problems” (WM = 4.36), indicate a strong agreement regarding the videos’ role in facilitating review, deepening understanding, and applying knowledge. These results mirror previous conclusions by Brame (2016), good instructional videos enhance clarity of concepts, enable students to review material at their own pace, and also promote application of learning in solving problems. Video-based visuals enable students to replay, stop, and process information at their own speed; this is quite useful in such complex topics as chemical bonding.

Lowest scoring statement of 4.34, corresponding to “The videos make the topic of chemical bonding easier to understand,” although still strongly agreed upon, suggests a slightly lesser degree of perceived impact in simplifying the topic. Overall, these findings demonstrate a consistently strong positive perception of the usefulness of the visual aid videos in supporting students’ learning experiences. This result resembles the findings of Aliyu et al. (2025), which indicated that even though the use of multimedia resources enhances understanding, certain abstract concepts in chemistry will also need further instructional guidance outside the video. Further explanations aside from the videos with either teacher guidance or interactive activities offer better understanding and avoid misconceptions in subjects that are difficult.

3) Engagement

Table 5. Analyzation of Visual Aid Videos in terms of Engagement

INDICATORS	MEAN	INTERPRETATION
The videos capture my attention from beginning to end.	4.28	Strongly Agree
The design and layout of the videos help sustain my concentration.	4.30	Strongly Agree

The videos encourage me to actively think about what I am watching.	4.32	Strongly Agree
The design and layout of the videos help sustain my concentration.	4.34	Strongly Agree
The videos make learning chemical bonding feel less intimidating and more fun.	4.36	Strongly Agree
OVERALL	3.01	Agree

The findings shown in Table 2.3 suggest that students strongly agree that the visual aid videos effectively engage them in learning chemical bonding, as reflected in the composite mean of 4.32. The highest rated statement, "The videos make learning chemical bonding feel less intimidating and more fun" (WM = 4.36), suggests that the videos successfully reduce anxiety and increase enjoyment during learning. This result aligns with the conclusions of Astuti et al. (2019) study, the findings demonstrated that VR classes increased student motivation while also improving their understanding of chemical structures. Instead of just reading, students could examine 3D models via VR - this hands-on approach clarifies difficult concepts. The results showed that combining technology with visual learning makes chemistry clearer and even more enjoyable. Items resulting in mean scores of average range, such as "The design and layout of the videos help sustain my concentration" (WM = 4.34) and "The videos encourage me to actively think about what I am watching" (WM = 4.32), highlight strong agreement that the videos maintain students' focus and promote active engagement. These results support the results presented by Cuenca et al. (2024), stating that high-quality and clear visuals have a great impact on students' readiness and participation in class discussions. The study shows that if the images are of very good quality students will pay more attention, participate more, and understand the lesson much easier. The learners' misunderstanding is lessened and the subject matter is clearer to them when pictures, charts, and multimedia resources are combined. Thus, the students are able to absorb the material better and are more than ready mentally for the discussion. Statement with minimal score of 4.28, corresponding to "The videos capture my attention from beginning to end," while still strongly agreed upon, indicates a slightly lower perception of the videos' ability to hold continuous attention throughout the entire duration. This result validates the conclusions reached by Sari et al. (2023), where even though multimedia greatly enhances engagement, attention span still varies depending on pacing, length, and cognitive load in the video. Students have a tendency to lose focus if the videos are longer or have dense information, even if visuals are included. Overall, these findings demonstrate a consistently strong positive perception of the visual aid videos' engagement value among students.

C. Effectiveness of Visual Aids in Enhancing the Understanding of Chemical Bonding

INDICATORS	MEAN	INTERPRETATION
Visual aids significantly improve my overall understanding of chemical bonding..	4.46	Strongly Agree
Lessons with visual aids keep me more engaged in the lessons of chemical bonding.	4.38	Strongly Agree
Visual aids help me understand abstract chemistry concepts more easily..	4.40	Strongly Agree
I retain bonding concepts longer when taught with visual aids.	4.32	Strongly Agree
Visual aids make me more confident to attempt bonding problems independently.	4.44	Strongly Agree
OVERALL	4.40	Strongly Agree

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The data in Table 3 reveal that students strongly agree on the effectiveness of visual aids in enhancing their understanding of chemical bonding, as reflected in the composite mean of 4.40. The statement with the top score, "Visual aids significantly improve my overall understanding of chemical bonding" (WM = 4.46), suggests that students perceive visual aids as highly beneficial in deepening their comprehension of the topic. This result appears to support outcomes noted by Dickmann et al. (2019) study, on how the student's ability to interpret visual models affects the way students conceptualize and perform in chemistry. Their findings proved that students who were able to interpret the represented visuals of molecular structures, bonding diagrams, reaction models, outperformed those who obtained information based on a purely textual approach to the explanation. The researchers concluded that visual models are important for the clarification of these abstract concepts in developing students' conceptual understanding.

Items with midpoint means include "Visual aids make me more confident to attempt bonding problems independently" (WM = 4.44) and "Visual aids help me understand abstract chemistry concepts more easily" (WM = 4.40), reflecting strong agreement that visual aids enhance confidence and facilitate understanding of challenging concepts. These results reinforce the findings of Çalık et al. (2024), meta-analysis indicating that instructional interventions with chemical bonding that involve visual and interactive tools significantly enhance students' conceptual understanding. It shows that visual tools work especially well in making abstract concepts concrete and rectifying common misconceptions regarding particle interaction.

The statement with the smallest score of 4.32, corresponds to the statement, "I retain bonding concepts longer when taught with visual aids," which, while still strongly agreed upon, indicates a comparatively lesser, yet positive, impact on long-term retention. This result is in line with the results of Mohammed et al. (2025), multimedia resources support retention in chemistry lessons but are most effective when partnered with repetitive practice and teacher scaffolding. Video learning alone may not sustain long-term memories without some reinforcement activities.

Overall, these findings demonstrate a consistent and strong positive perception of the effectiveness of visual aids in supporting students' learning of chemical bonding.

V. CONCLUSIONS

The research findings show that visual aids prove to be an excellent tool for helping first-year Geodetic Engineering students at Batangas State University – Alangilan Campus understand chemical bonding better. The research results show that students face major obstacles when studying chemical bonding because they struggle to understand symbols and abstract representations and notation systems. The high composite mean of 4.14 shows that students face major learning difficulties which traditional teaching methods cannot solve effectively.

The survey results show that visual aids received high agreement ratings from students across all assessment criteria which included explanation and usefulness and engagement and overall effectiveness. The visual aid videos delivered precise and relevant explanations about fundamental bonding principles which helped students understand classroom material better. Students reported that these educational resources enhanced their ability to remember schoolwork and simplified complicated subjects while making study preparation easier. The visual aids demonstrated their usefulness by enabling students to solve problems independently while applying learned concepts to practical situations. The visual aids created an engaging learning environment which helped students feel less anxious about chemistry while making them more enthusiastic about studying. The videos kept students focused while encouraging them to think actively and created a positive learning experience. The students maintained high levels of engagement but showed a slightly lower ability to stay focused from start to finish. The visual aids achieved a high composite mean of 4.40 which demonstrates their effectiveness in helping students understand chemical bonding better. Visual models and diagrams made complex ideas more accessible while boosting students' bonding problem-solving abilities and their ability to retain information when they received additional practice activities. The implementation of visual aids during chemistry lessons produces excellent results for first-year Geodetic Engineering students. Visual aids help students overcome learning obstacles while improving their understanding of chemical bonding and their class participation and academic results. The research evidence supports using visual educational resources to enhance chemistry learning by overcoming student challenges and creating an active learning space.

VI. RECOMMENDATIONS

Based on findings, the study recommends that teachers continue using visual aids like videos, diagrams, and animations because these make chemical bonding easier to understand and help the students stay focused during the lesson. Pairing visual aids with short explanations or quick activities can also help students remember the topic better and clear up common misconceptions. Future researchers may try using other visual materials or teaching approaches that simplify difficult chemistry concepts. It would be also helpful to conduct the study with more students so the result can reflect on a wider group.

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The study recommendations part of this study offers suggestions based on the study's findings. It seeks to provide actionable guidance and solutions to help students better understand chemical bonding through the use of visual aids.

Firstly, the students can improve their learning by using visual materials like videos, diagrams, and animations during study sessions. Using visual aids may help them understand and remember chemical bonding concepts more easily, especially in topics they find difficult or confusing. Using these materials can also make it easier to see how atoms form bonds and understand the lesson more clearly. Secondly, because chemical bonding is one of the challenging topics in chemistry, instructors are encouraged to use different visual materials, like videos, diagrams and animation to help students better understand and retain the lesson. By clearly showing how different elements interact, these tools not only improve comprehension but also increase students' interest and engagement in the class. Furthermore, the use of visual materials by instructors can also help students better understand various abstract concepts Lastly, The researchers are encouraged to conduct related studies to explore additional ways visual aids can help students to understand chemical bonding better. The future researchers are recommended to improve and expand the study to further enhance students' learning of chemical bonding. By building on the current findings, they can examine additional aspects or factors that may affect understanding, such as different ways of presenting visual aids, combining them with other teaching strategies, or finding approaches to support difficult topics.

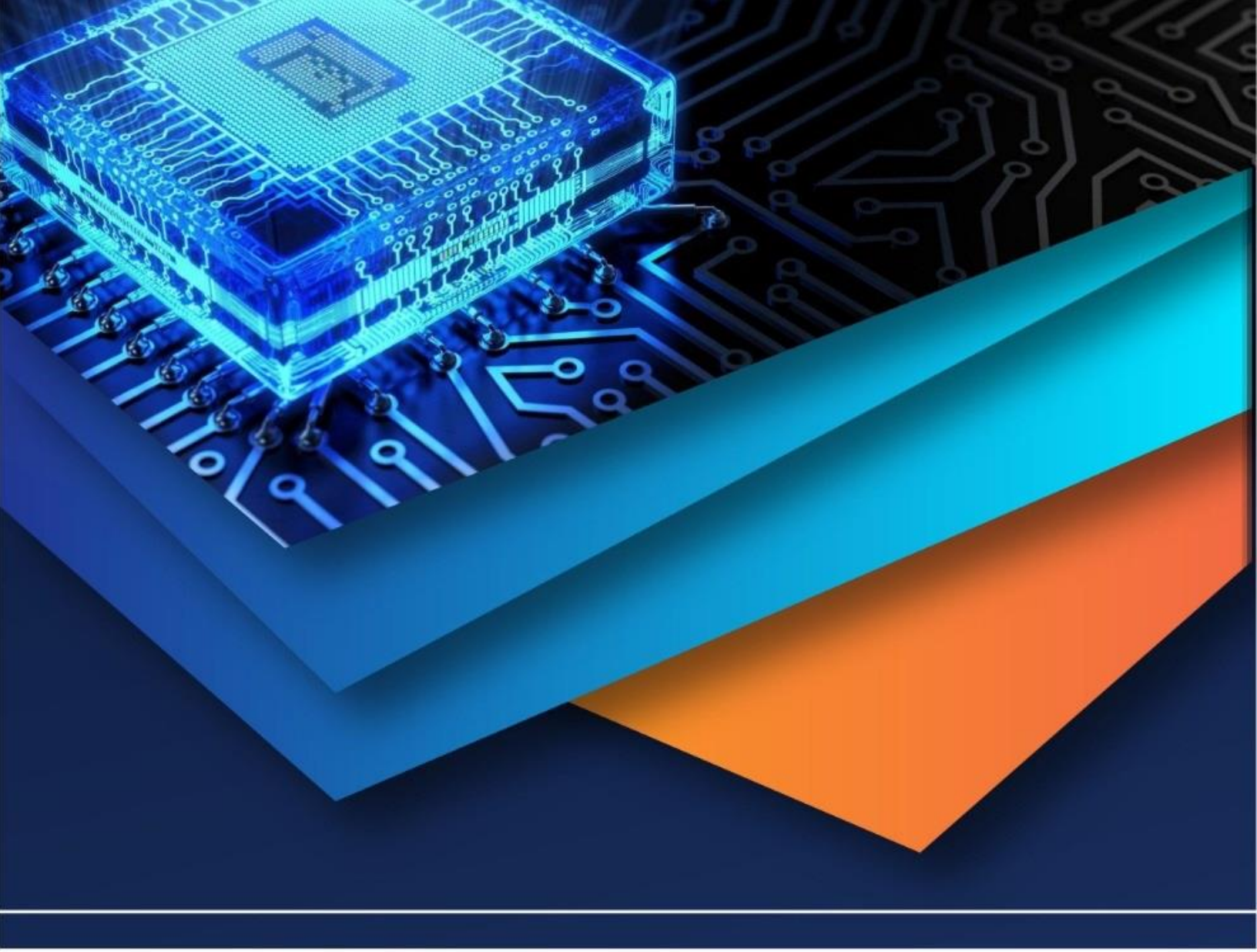
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