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Sustainable Innovation and Student Entrepreneurship in Engineering

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Abstract: ***The research described in this paper investigates the impact of engineering programs, with a sustainability component, on student entrepreneurship. Educating future engineers on sustainable technologies and encouraging sustainable innovations and student entrepreneurship is a critical and growing need. Historically, engineering student entrepreneurship and subsequent licensing and startups have been encouraged and supported in several ways, including technology transfer offices and community engagement. The question this study attempts to answer is whether more student entrepreneurship resources and programming should be allocated to engineering programs that include sustainability content, courses, or programs.***
Keywords: Sustainability, Entrepreneurship, Engineering Education, Technology Transfer

I. INTRODUCTION

Sustainable innovation 0is a continuously changing field where the focus on technological innovation has shifted toward human-centered innovation [1]. For several years, the importance of sustainable innovation has grown at a fast pace. Universities, including students, play a vital role in sustainable innovation through research, education, and community outreach [2]. As a player in sustainable innovation, do universities foster sustainable innovation among students and subsequent transfer of technology from academia to society? As a follow-up, what processes or mechanisms do universities and their technology transfer offices use to support the development of and transfer of sustainable innovations? Finally, should universities target entrepreneurship resources toward students in sustainability-related engineering courses?

Sustainable innovations, according to Manual, can be divided into four categories: product innovations, process innovations, marketing innovations, and organizational innovations [3]. Within the categories, innovations range from small improvements to disruptive technologies. To enhance sustainable innovations in academia or business, the literature suggests several factors described below [3].

1) Resources and capabilities: aligning resources and capabilities to support sustainable innovation.
2) Structures and processes: reconfiguring structures and processes to support sustainable innovation.
3) Organizational culture: create a culture that values sustainability.
4) Leadership and commitment: secure management's commitment to supporting and valuing sustainable innovation.

There are some specific examples of universities specifically supporting sustainable innovation and entrepreneurship. For example, the University of Wisconsin-Madison promotes DOE Office of Technology Transitions funding opportunities on its UW-M Technology Entrepreneurship Office website [4]. The University of Kentucky promotes social innovation through its "growing through social innovation" webinar series, which covers topics such as funding opportunities and impact measurement. Finally, the University of Calgary has multiple innovation hubs, such as the social innovation hub. This hub offers a variety of programs and funding opportunities, partnering with Innovate Calgary [5].

Regarding general engineering entrepreneurship education, in a study conducted in 2010, entrepreneurship in engineering education was analyzed at 340 ASEE member schools. Over half of those schools provided some engineering entrepreneurship education, with approximately 25 percent offering minors and other more substantial programs such as concentrations or certificates [6]. Of the schools surveyed, the engineering entrepreneurship programming was a collaboration between the engineering and business departments [6].

While there has been research on general entrepreneurship in engineering education, this study discusses how some universities and technology transfer offices specifically view sustainable innovation and engineering student entrepreneurship. It also discusses whether entrepreneurial resources should be targeted toward students in sustainability-related engineering courses or programs.

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II. METHODOLOGY

The study began by identifying a sample of schools with engineering programs that contain some form of sustainable engineering or technology education and have a technology transfer office. Fifteen schools were identified, comprising a mix of R1 and R2 schools, with the majority being R1. The research questions below were emailed via a Google survey form to technology transfer personnel in the respective 15 schools. The results were collected, analyzed, and subsequently summarized in the results section below.

1) Do you work in Technology Transfer at your university or college (either part-time or full-time)?
2) What is your job title?
3) Does your college or university offer academic programs in engineering (either undergraduate or graduate)?
4) Do any of the engineering programs offer courses that include sustainability concepts?
5) On average, how many total invention disclosures does your technology transfer office receive annually?
6) Approximately, what percentage of those disclosures come from students (undergraduate and graduate combined)?
7) Over the past 5 years, has your Technology Transfer Office received invention disclosures from students (undergraduate or graduate) involving sustainable technologies?
8) Has any sustainable technology disclosure submitted by a student (undergraduate or graduate) in the past 5 years resulted in a license?
9) Has any sustainable technology disclosure submitted by a student (undergraduate or graduate) in the past 5 years resulted in a student-led startup?
10) Would it be valuable to provide sustainability-focused entrepreneurial education and resources for students in sustainability-related engineering courses and/or programs?
11) Please share any comments on student-developed sustainability innovations and/or sustainability entrepreneurship at your college or university.

III. RESULTS

Of the 15 schools surveyed, 4 responses were received. All respondents worked in technology transfer either full-time or part-time. Their job titles were Technology Manager, Director of Technology Commercialization, Associate Director, Licensing, and Associate Director, Science & Engineering Technology Transfer. As shown in Figures 1 and 2, respectively, all 4 schools that responded have engineering programs. Of the 4 respondents, 3 indicated their schools offer courses with sustainability concepts while the fourth respondent was unsure.

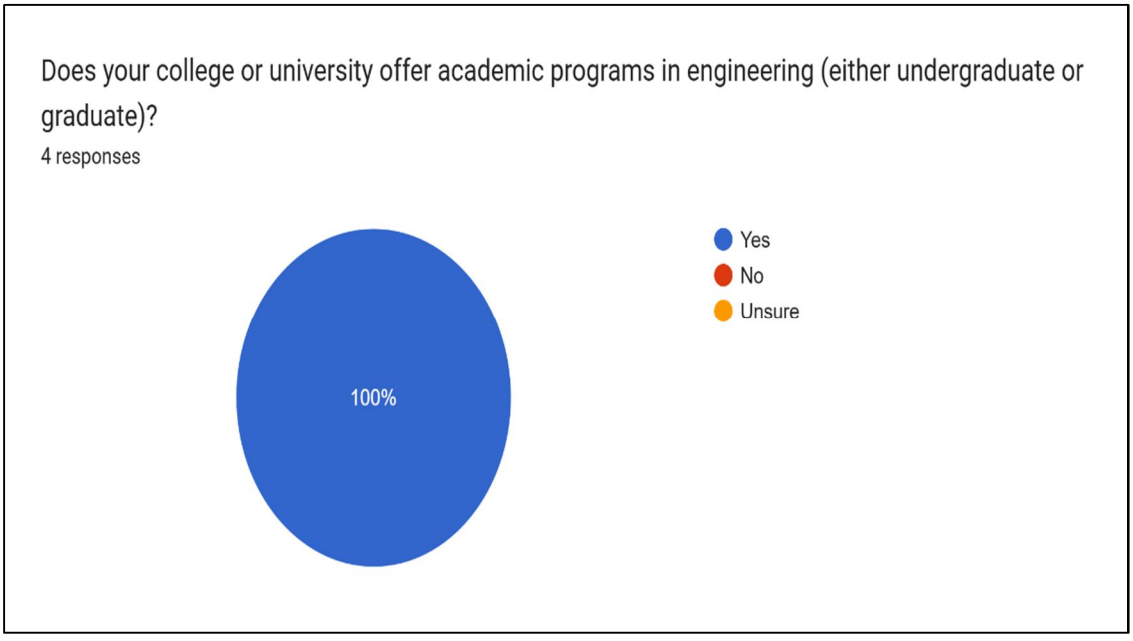


Fig. 1 Does your college of university offer academic programs in engineering (either undergraduate or graduate)?

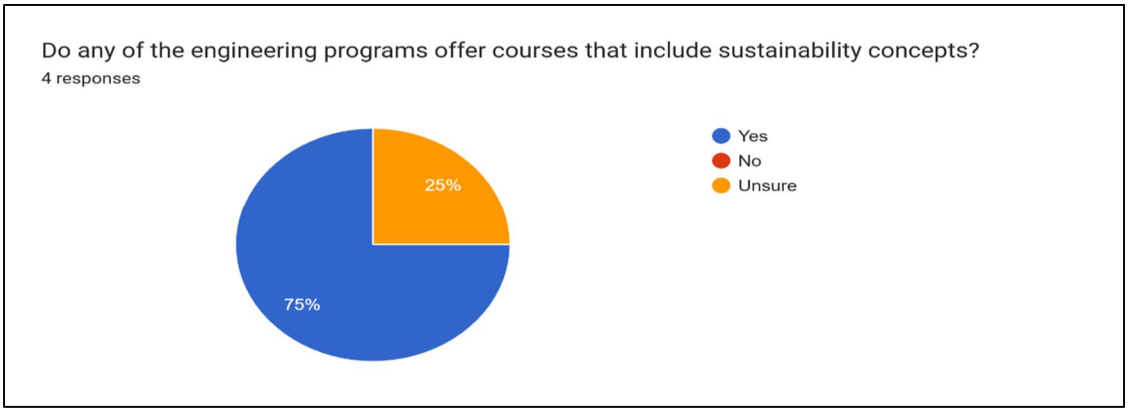


Fig. 2 Do any of the engineering programs offer courses that include sustainability concepts?

Figure 3, below, shows that all the technology transfer offices that responded received at least 21-30 invention disclosures per year, with several reporting over 50. Of those invention disclosures, as seen in Figure 4, 1 percent to over 30 percent came from students (undergraduate and graduate combined).

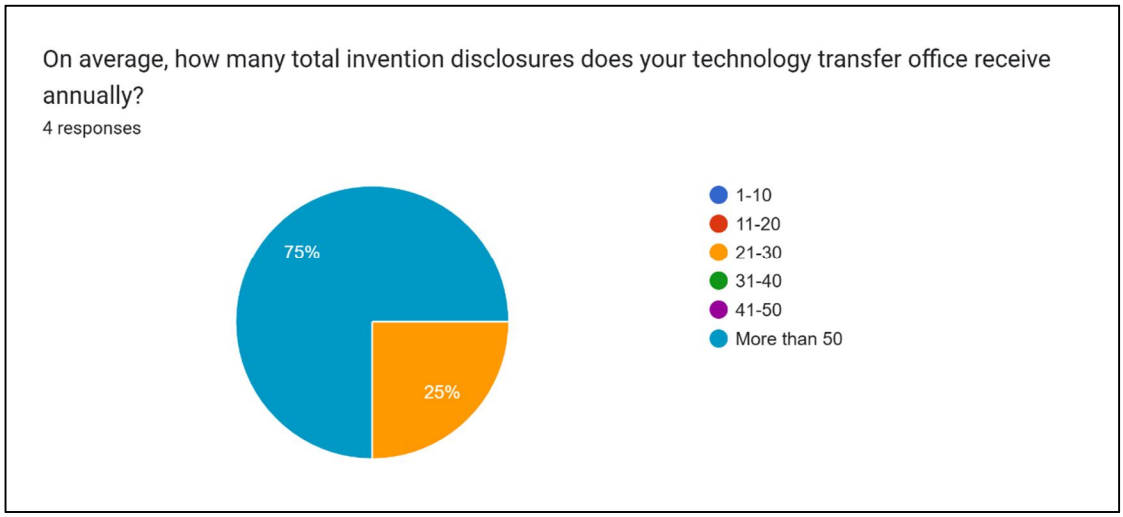


Fig. 3 On average, how many total invention disclosures does the technology transfer office receive annually?

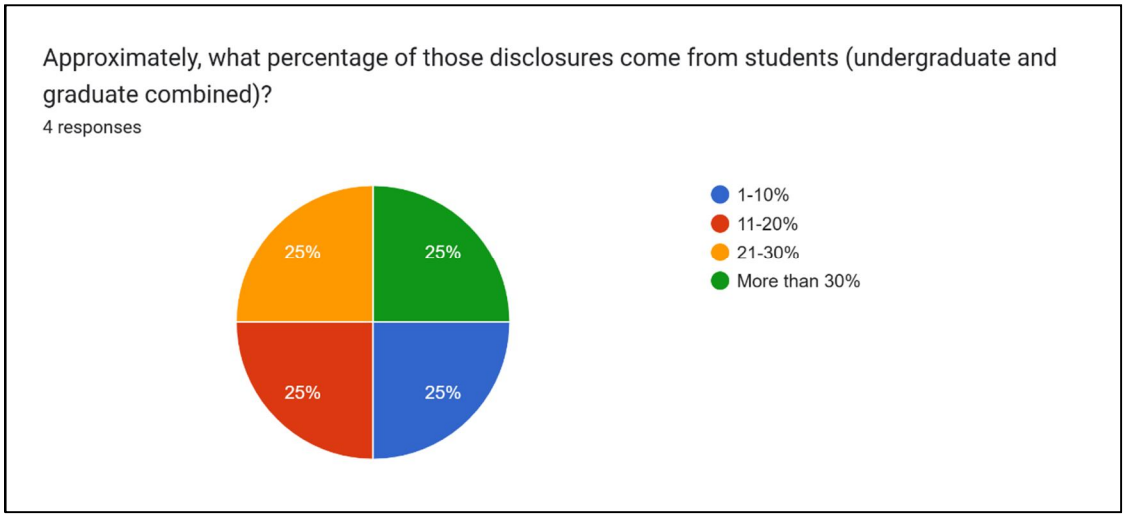


Fig. 4 Approximately, what percentage of those disclosures come from students (undergraduate and graduate combined)?

All schools that responded indicated they received student invention disclosures in the past 5 years involving sustainable technologies as shown in Figure 5. Of those, one school reported that at least one invention disclosure led to a license, shown in Figure 6. Figure 7, illustrates that 3 of the 4 respondents indicated some student innovations involving sustainable technologies led to a student-led startup.

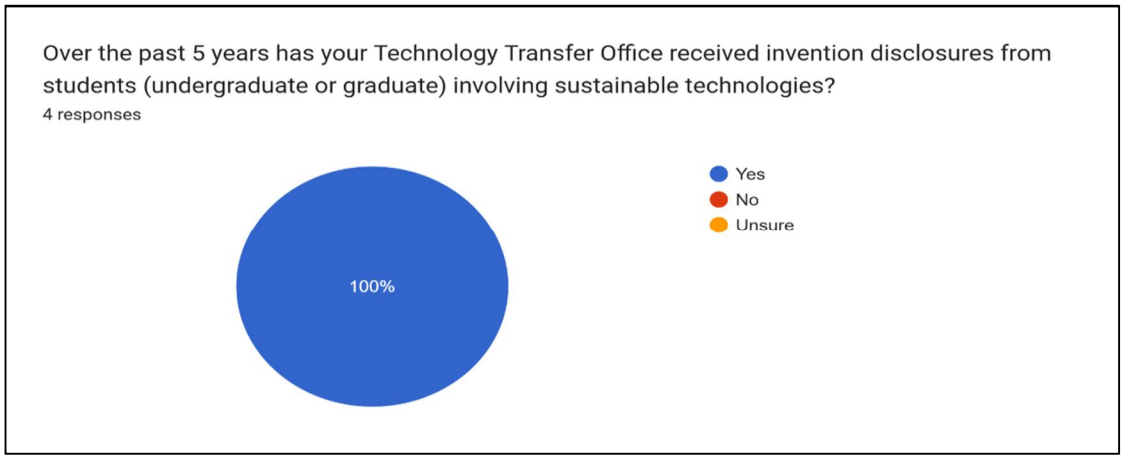


Fig. 5 Over the past 5 years, has your Technology Transfer Office received invention disclosures from students (undergraduate or graduate) involving sustainable technologies?

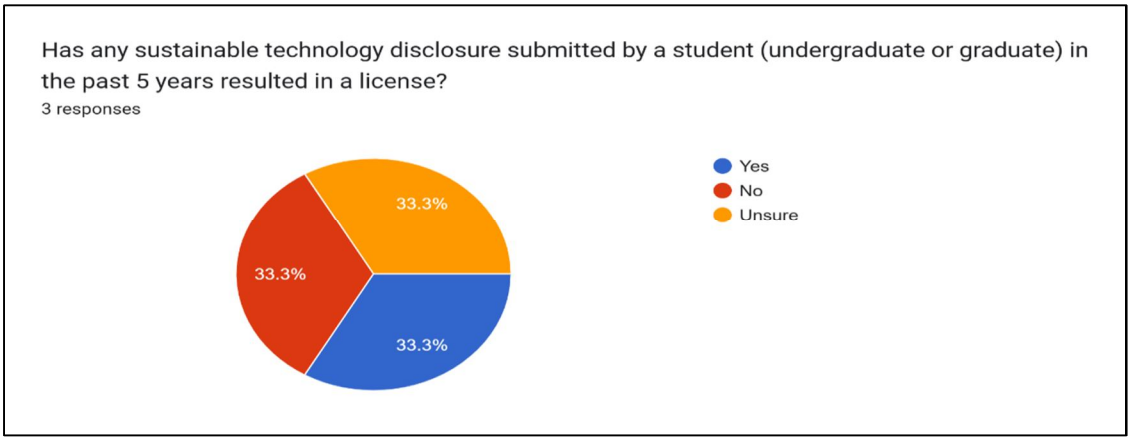


Fig. 6 Has any sustainable technology disclosure submitted by a student (undergraduate or graduate) in the past 5 years resulted in a license?

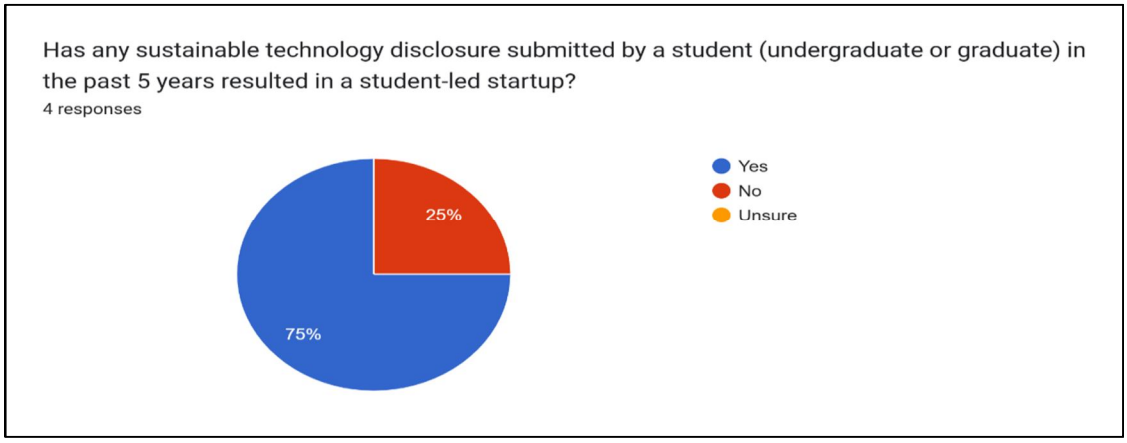


Fig. 7 Has any sustainable technology disclosure submitted by a student (undergraduate or graduate) in the past 5 years resulted in a student-led startup?

Finally, 3 of the 4 schools indicated, as shown in Figure 8, that it would be valuable to have sustainability-focused entrepreneurial education and resources for students in sustainability-related engineering courses and/or programs.

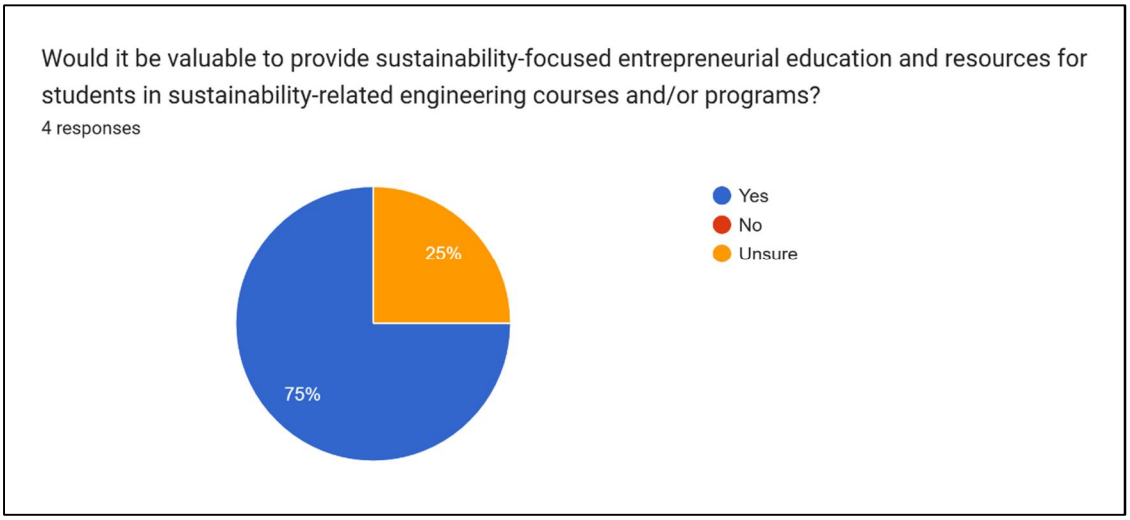


Fig. 8 Would it be valuable to have sustainability-focused entrepreneurial education and resources for students in sustainability-related engineering courses and/or programs?

Below are additional comments from respondents on student-developed sustainability innovations and/or sustainability entrepreneurship at their college or university.

"Most in invention disclosures, we receive come from federally funded research programs often the graduates student is included as a coinventor in some cases. The grads or post doc is interested in starting a business, but this is infrequent. We are aware there are some entrepreneurial courses being offered in the engineering college, but unsure of the outcomes and contribution to student startups at iron institution. There is active discussion to increase entrepreneurial training and exposure to students."

"I would estimate that about 1/3 of our disclosures have a sustainability component to them. Grad students are the lead inventor for about half of these, with faculty advisors playing a supporting role. With a large portion of our grad students international, we are leveraging the Global EIR program from Global Detroit to help assist with Visa issues. I-Corps and other innovation workshops have been helpful for guidance and investment decision for IP, etc..."

"Sustainability should be taught in an economic context. Sustainability as a main focus is not sustainable, because it is then susceptible to a changing political or economic climate. In the end, sustainability must function as a part of a larger economic benefit."

IV. CONCLUSIONS

Based on the literature review, teaching entrepreneurship in engineering education or exposing engineering students to entrepreneurship has been growing for at least the past 17 years. The exposure ranges from introducing entrepreneurial concepts in engineering courses to more structured programs such as an entrepreneurship minor. The literature also recognizes several colleges and universities target social innovation and social entrepreneurship. However, the literature review does not suggest any schools align entrepreneurship resources to engineering students specifically in sustainability related courses and programs.

The research conducted in this study of technology transfer offices at schools with engineering programs confirms that engineering students are submitting invention disclosures to their respective technology transfer offices and a percentage of those involve sustainable technologies. Interestingly, some of those invention disclosures resulted in licenses and student-led startups.

Based on the written responses collected, it would be valuable to provide targeted entrepreneurial education and resources to students in sustainability-related engineering courses and/or programs. The additional comments from respondents indicated that many of the student inventors were graduate students or post-doctoral students and generally not interested in starting a business. Many graduate students are international students which present visa challenges. However, while those issues are challenging, there are ways to solve them. It is recommended that this study be continued to provide more robust data, results, and conclusions. For example, continuing the literature review would be beneficial. Also, continuing to review how engineering entrepreneurship is related to sustainable technology education at more engineering schools will be beneficial to the study. Finally, increasing the total number of survey responses by utilizing mailing lists from organizations such as AUTM or others would be helpful.

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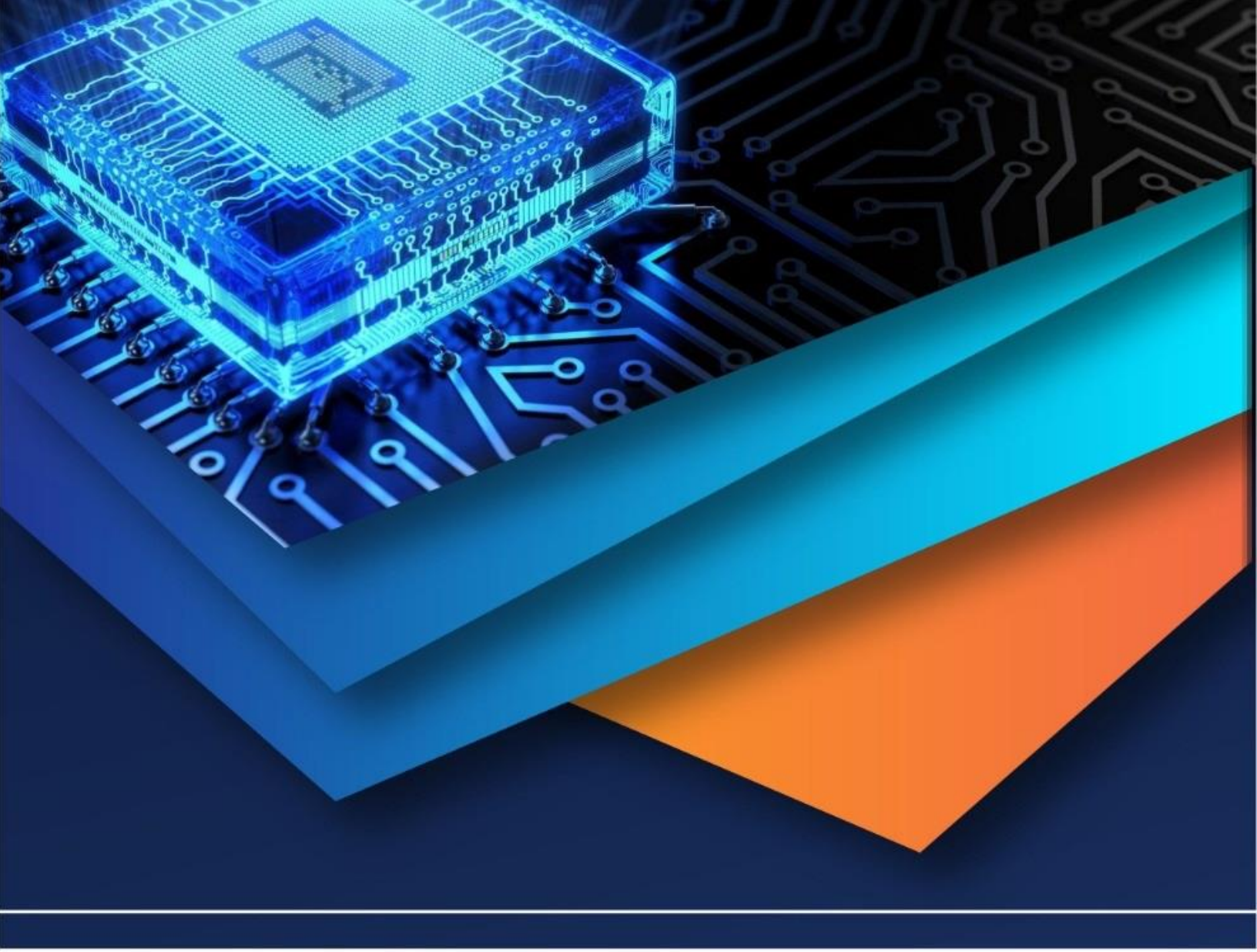
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