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Perceptions Towards the Use of Drones in Learning Among Mechanical and Manufacturing Engineering Students

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Abstract

In the 4.0 revolution, drone technology is a key technology in the field of automation and robotics. The goal of the National Space Agency in providing active space exposure by 2030, involves the advancement of drone technology in assisting human tasks in various fields. The technology development process takes a long time to achieve this goal. Various factors such as existing understanding, knowledge, skills, and acceptance of drone technology should be studied. Therefore, this study aims to identify the perception of understanding, acceptance, and application of drones among students of the Faculty of Mechanical and Manufacturing Engineering (FKMP) of UTHM. This survey study uses a quantitative approach by distributing a questionnaire to 241 students of the Faculty of Mechanical and Manufacturing Engineering (FKMP) of UTHM to study the perception of understanding of drones, the acceptance of drones in learning, and the application of drones. Data were analyzed using descriptive statistical analysis. Descriptive analysis was conducted by taking the mean score and standard deviation. The results of the study found that the perception of understanding of drones shows a high level due to the widespread use of drones in various fields. The perception of the acceptance of drones in learning shows a high level which also proves the willingness of students to explore this technology more deeply. Meanwhile, the application of drones is at a medium-high level showing mastery of skills or knowledge to be applied to drone technology still needs improvement to realize the 2030 goal of active space exposure. This study suggests that drone-related programs involve the participation of students from other fields to integrate various skills and knowledge in the exploration of drone technology.

1. Introduction

The domain of space encompasses activities that contribute to the national economy, including navigation, communication services and remote sensing (Agensi Angkasa Negara, 2017). The objective of reforming space capabilities is to enhance productivity and establish the nation as a developed country through advancements in space technology and infrastructure. To accomplish this, emphasis should be placed on prioritizing research in space science, technology, and innovation, with a specific focus on engineering that generates user-friendly and time-saving advancements. However, the limited skills and execution pose a potential obstacle to students' exposure to practical applications and their potential contributions to society (Md Hassan et al., 2021). A promising area for growth lies in the field of drone engineering, which holds significant potential in various sectors such as agriculture, reconnaissance, photography, and search and rescue operations. The United States, for instance, has plans to generate 100,000 job opportunities related to drones by 2025 to meet the increasing demand for professionals involved in drone control, design, maintenance, and programming (Abichandani et al., 2022).

The expertise and proficiency in drones are widely recognized by educators and scholars due to their extensive application in the field of education, which contributes to an enhanced learning experience and improved academic performance (Shadiev & Suping, 2022). The utilization of drone technology has the potential to augment the process of teaching and learning by affording students the opportunity to explore the pedagogical capabilities of these devices and apply their theoretical knowledge to resolve real-world issues (Shadiev & Suping, 2022). The effective implementation of drone-related skills and knowledge necessitates the provision of local research and development support (Hashim et al., 2021). Instructors or individuals with adequate proficiency must possess the requisite skills and knowledge to operate the drone effectively in order to ensure a safe learning environment. Additionally, students can be educated on maintenance and technical knowledge to guarantee the optimal functioning of the drone (Nik Hashim et al., 2018). To fully harness the benefits of drone technology, it is imperative to have a sustained and continuous utilization of these devices, as well as the development of strategies and resources, including legislative measures to address concerns related to privacy, ethics, security, and monitoring (Kutynska & Dei, 2023). The Malaysian Remote Sensing Agency (ARSM) assumes responsibility for the research and development of remote sensing applications within the nation, intending to fortify engagement in space-related activities and international networks.

1.1 Understanding of Drone Technology

The drone has developed into an innovative solution to meet various needs of the public in various industries, such as construction, mining, education, and healthcare. In education, drones are used as appropriate teaching tools for various levels of study (Novianto et al., 2022). Drone development requires knowledge of software and communication systems, through technology-based courses to allow students to be constantly updated with the latest developments (Novianto et al., 2022). Understanding drone technology involves various subjects such as mathematics, physics, coding, and ethics (Djatmiko et al., 2021). These subjects form the basis for planning, controlling, and communicating the drone (Danardono et al., 2020). Integrating these subjects into the curriculum provides a comprehensive understanding of drone technology, preparing students for the challenges and opportunities in the drone industry.

Rochaeni (2019) found that drones help students focus and understand the learning process. The trend involving teaching based on robotics and programming is becoming more widespread among educators because it can provide a fun and attractive experience with technology. However, the integration of drone technology in education still has limited research (Nik Hashim et al., 2018). Therefore, Nik Hashim (2018) suggested that teachers need to be prepared with the necessary skills to improve the quality of learning science, technology, innovation, and computer skills to ensure the integration of drones in effective learning.

1.2 Adoption of Drones Technology

Drone knowledge can be linked to TVET by providing skills and knowledge for drone production. TVET prepares students for drone training and development with exposure to hands-on training with drone technology. Drones facilitate knowledge sharing through leadership, culture, human capital, technology training, and management. According to a study, drones improve students' understanding of *Reka Bentuk Teknologi* (RBT) (Ramli & Osman, 2023). Experimental studies show positive effects on students' interest and motivation. Drones include technical skills and theoretical knowledge, which engage students in problem-solving and expose them to new technologies (Joyce et al., 2020; Ryu et al., 2020). Given an example, military academies are incorporating drones into their curriculum, leading to drone-related job opportunities for graduates (Inga & Pereira, 2021).

The use of drones in education is not limited to secondary schools but also benefits primary schools and leads to the investigation of Doctor of Philosophy at public universities (Abd Rahman et al., 2018; Bai et al., 2021; Siguerdidjane & Sordi, 2020). Drone technology enhances learning by maximizing exposure to technology through equipment and virtual reality. It fosters innovative thinking, orientation skills, and cost-effective design. The use of drones increases curiosity, imagination, and the application of theory to the real world. Studies have shown that exposure to drones is as valuable as real-world experiences for students (Paulauskaite Tarasevicienе et al., 2022). To achieve the positive effects of drone use in learning, instructors must be innovative in implementing classroom instruction (Delavarpour et al., 2021). Higher education can involve industry stakeholders to guide academic citizens and promote knowledge and skills sharing. Collaboration between higher institutions and industry is essential to ensure a uniform curriculum that benefits society. Drones have various capabilities in promoting critical thinking and providing learning opportunities in STEM careers (Sattar et al., 2017). Drone learning promotes deeper skills.

1.3 Applications of Drone Technology

The transfer of knowledge and skills in the curriculum system involves solution, planning, and evaluation (Behjat, 2021). Problem-based learning is an active methodological foundation in pedagogical learning. Pedagogical processes involve the use of technology and effective learning. Instructors need computer skills, internet networking applications, and data analysis for drone learning sessions. At the vocational college level, there is a gap in instructor development and technological resources that impact learning outcomes. Some instructors do not optimize technological resources, explore new technologies, and have inadequate tools to limit exposure to drone technology (Wu & Mao, 2023). AI technology can solve these issues with adaptive learning systems. The Knewton Adaptive Learning Platform AI system provides training and modules to students individually. This involves teaching methods, assessing and diversifying technology-based teaching approaches which give a positive impact on instructors and students (Wu & Mao, 2023).

Chou (2018) stated the effect of using drones on student behavior in learning and programming shows a high interest and motivation to be actively involved in learning sessions. A study from McGoldrick et al. (2016) has discussed the challenges faced by educators to integrate drones into learning is an effort to combine practical learning and students' existing experience/knowledge towards the use of drones. Next, this study also contributes to explaining the function of how existing undergraduate and postgraduate course materials from different engineering disciplines can be improved to address and solve various aspects of challenges related to drones. Engineering design needs to be integrated across the engineering curriculum. A key element in technology development is professional skills that explicitly foster and instill lifelong learning skills to directly benefit all learners, regardless of expertise (McGoldrick et al., 2016). For example, computer engineering can combine elements of mechanical and electrical engineering in the production of a new technology.

2. Methodology

This study employs a survey research design utilizing a descriptive quantitative methodology to investigate the perception of comprehension, the acceptance of drones in educational settings, and exposure to the application of drones to enhance the utilization of drones in engineering education. Through this quantitative approach, the researcher has employed an instrument in the form of a questionnaire that is conveniently accessible using Google Form and Quick Response (QR), administered to students from the Faculty of Mechanical and Manufacturing Engineering (FKMP) at Universiti Tun Hussein Onn Malaysia (UTHM). This structured questionnaire necessitates respondents to select from a limited range of answers, ensuring a concise and efficient data collection process that facilitates ease of analysis.

2.1 Study Participants

The study involved students from the Faculty of Manufacturing Mechanical Engineering at the University Tun Hussein Onn Malaysia. Random sampling was used to select students believed to have used drones in their learning sessions. The pilot study included 30 respondents out of a total of 2003 students, with 1973 respondents for the actual study. The sample determination table by Cohen et al., (2001) was used with a confidence level of 90%, the minimum sample size required is 240 respondents. This study has taken a total of 241 respondents sufficient for the minimum number required to conduct the study. To ensure the validity of this study, students who participated in the pilot study were excluded from the actual study. Steps were taken to limit each respondent to one questionnaire response using Google Forms. Respondents could only provide feedback once using a confirmed email address. Email addresses were not stored to protect respondent privacy and maintain ethical standards in data collection.

2.2 Instrument

A research instrument is a tool or technique used to collect, measure, and analyse data related to the study. The researcher used an online questionnaire as an instrument to facilitate the question-and-answer session. The Google Form platform is used to retrieve respondents' feedback during face-to-face meetings. The questionnaire distributed to students of the Faculty of Mechanical and Manufacturing Engineering (FKMP) uses QR scanning to facilitate students access simultaneously, but one email is limited to answering only once. This questionnaire was adapted from a combination of journals from previous researchers from Abd Rahman et al., (2018), Barr (2023), Lobo et al., (2021), Shatanawi (2022) and Ramli & Osman (2023).

This questionnaire is divided into four parts, namely Part A on the demographics of the respondents, Part B on the perception of basic understanding and response to drones, Part C on the perception of the acceptance of drone technology in learning, Part D on the exposure of the application of drone technology. The questionnaire items in Parts B, C and D are measured using a 5-point Likert scale, score ranging from 1, indicating strongly disagree, to 5, indicating strongly agree.

2.3 Research Analysis

Data analysis is conducted after the survey questionnaire has been collected through Google Forms. The descriptive analysis used by the researcher refers to the percentage, mean score, and standard deviation of each item in the instrument. The mean score interpretation is based on the Mean Score Scale by Nunnally and Bernstein (1994) as shown in Table 1, which was used in the study of Sa'aban, Abdul Ghani dan Muhammad Faizal Darusalam (2017).

Table 1 *Mean Score Interpretation Scale (Nunnally & Bernstein, 1994)*

Mean Score	Interpretation Mean Score
1.00 – 2.00	Low
2.01 – 3.00	Medium Low
3.01 – 4.00	Medium High
4.01 – 5.00	High

3. Results and Discussion

3.1 Analysis of Exposure to Drones

Based on the data, the distribution of respondents on knowledge of drones in the Faculty of Mechanical and Manufacturing Engineering (FKMP) shows that most of the respondents have been exposed to drone technology. The results show that 14 (5.8%) students do not know/ have no exposure to drones and 227 (94.2%) students know/ have exposure to drones. For the bachelor's study level, a total of 10 (4.15%) students do not know about drones, while 210 (87.14%) students know about drones. At the master level, a total of 4 (1.66%) students do not know about drones and 16 (6.64%) know about drones. Finally, one (0.41%) Doctoral student knew about drones. Table 2 shows the distribution of respondents on knowledge of drones.

Table 2 *Distribution of respondents on knowledge of drones*

Level of Study	Knowledge of drones	
	Do not know	Know
Bachelor's Degree	10 (4.15%)	210 (87.14%)
Masters	4 (1.66%)	16 (6.64%)
Doctorate	0 (0%)	1 (0.41%)
Total	14 (5.81%)	227 (94.19%)

3.2 Perception of Understanding of Drones

Table 2 presents the findings of descriptive analysis of respondents' basic understanding of drones. The analysis revealed that the overall perception regarding the understanding of drones was notably high, as evidenced by a mean score of 4.31 and a standard deviation of 0.57. By Nunnally and Bernstein's (1994) framework, which asserts that a value between 4.01 and 5.00 is indicative of a high level, it can be inferred that respondents possessed a positive comprehension of drone usage and were inclined to agree with the statements provided.

Based on the table, it is evident that the item with the highest mean score was B11, which pertains to the notion that "I think drones are something fun." This statement garnered a mean score of 4.63 and a standard deviation of 0.55, signifying a strong agreement among the respondents. Additionally, the item with the second highest mean score was B5, which addresses the belief that "I think drone use will probably save time in agriculture/monitoring." This statement received a mean score of 4.60 and a standard deviation of 0.62, further affirming the respondents' strong agreement. Conversely, the item with the lowest mean score (3.65) and standard deviation (1.37) was B3, which examines the confidence in explaining drone-related information to others. This finding suggests that respondents were more inclined to express directional agreement only. Overall, the mean scores relating to the understanding of drones were predominantly at a medium-high and high level.

It is noteworthy to mention that there were several items for which no respondents expressed strong disagreement (0%). These items include B6 "I think the use of electric drones may reduce air pollution", B8 "I think using drones can increase productivity", B9 "I feel the time spent on these drone-related activities is beneficial", B10 "I see the value of learning in drone-related activities", and B11 "I think drones are beneficial". Such a unanimous lack of strong disagreement indicates the perceived positive and enjoyable nature of these aspects.

Table 3 *Descriptive analysis of respondents' basic understanding of drones*

Item	Statement	Mean Score	Standard Deviation	Interpretation Mean Score
B1	I am aware of the concept of drones.	4.45	0.898	High
B2	I am familiar with the topic of drones.	3.86	1.295	Medium High
B3	I am confident that I can explain information related to drones to anyone	3.65	1.374	Medium High
B4	I have knowledge about the use of drones.	3.93	1.218	Medium High
B5	I think the use of drones will probably save time in the field of agriculture/monitoring.	4.60	0.625	High
B6	I think the use of electric drones may reduce air pollution.	4.56	0.693	High
B7	I think the use of drones may reduce the number of accidents that take lives.	4.49	0.796	High
B8	I think using drones can increase productivity.	4.59	0.593	High
B9	I feel that the time spent on these drone-related activities is worthwhile.	4.46	0.718	High
B10	I see the value of learning in drone-related activities.	4.30	0.803	High
B11	I think drones are fun.	4.63	0.555	High
Overall Score				
Mean Score		4.319		
Standard Deviation		0.575		
Level		High		

3.3 Perception of Acceptance of Drone Technology in Learning

Based on the data presented in Table 3, the findings indicate that the overall perception of drone reception in the context of learning was highly favorable. The mean score recorded was 4.29, with a standard deviation of 0.49. The statement that received the highest mean score was item C1, which pertained to the interest in utilizing drones. The mean score for this item was 4.59, with a standard deviation of 0.66. It is worth noting that respondents' responses leaned more towards strongly agreeing with this statement, although there was some agreement as well. The second highest mean score, at 4.49 with a standard deviation of 0.69, was observed for item C6, which explored the perception that using drones can enhance the learning process. Respondents generally agreed with this statement. On the other hand, the lowest mean score was recorded for item C16, which focused on concerns about the liability of laws related to drone ownership and control. The mean score for this item was 3.64, with a standard deviation of 1.11, indicating a moderately high level of agreement among respondents. The overall interpretation of the mean score on the acceptance of drones in learning is at a medium-high and high level only.

Some items record no respondents who strongly disagree (0%) with item C1 "I am interested in using drones", C6 "I think using drones will make the learning process more interesting", C8 "I think drones can integrate knowledge from various fields to strengthen the learning process", C9 "I think learning will be more fun by using drones as a practical exercise", C10 "I think drones can motivate in my field", C11 "I think the involvement of drones in the curriculum will give satisfaction in a learning session", C12 "Safety and privacy factors significantly affect your acceptance of the use of drones?" and C13 "Benefit factors of drone use significantly affect acceptance of drones?" In other words, there was unanimous agreement or lack of strong disagreement among respondents regarding the interest in using drones, the potential for drones to enhance the learning process, the integration of science from various fields, the fun aspect of using drones for practical exercises, the motivational boost provided by drones, the satisfaction derived from incorporating drones in the curriculum, the impact of safety and privacy factors on the acceptance of drone use and the influence of the benefits of drone use on acceptance.

Table 4 *Descriptive analysis of the adoption of drone technology in learning*

Item	Statement	Mean Score	Standard Deviation	Interpretation Mean Score
C1	I am interested in using drones.	4.59	0.666	High
C2	I want to learn about drones.	4.43	0.824	High
C3	I am excited to gain knowledge and skills related to drones.	4.38	0.901	High
C4	I enjoy learning about the latest drone technology.	4.03	1.276	High
C5	I have a good experience of using drones.	4.21	1.095	High
C6	I think using drones will make the learning process more interesting.	4.49	0.690	High
C7	I think that drones can provide information on any operation more quickly and easily.	4.48	0.696	High
C8	I think drones can integrate knowledge from various fields to strengthen the learning process.	4.46	0.713	High
C9	I think learning will be more fun by using drones as a practical exercise.	4.46	0.645	High
C10	I think drones can provide a motivational boost to my field.	4.37	0.795	High
C11	I think the involvement of drones in the curriculum will provide satisfaction in the learning session.	4.48	0.671	High
C12	Safety and privacy factors significantly affect your acceptance of drone use?	4.32	0.703	High
C13	Factors that benefit the use of drones have a significant impact on the adoption of drones?	4.40	0.639	High
C14	I am concerned about data privacy when using drones (for example, disclosure of destination/location to third parties).	3.98	1.045	Medium High
C15	I am concerned if the drone system fails to operate during any adverse conditions (for example, heavy rain, fog).	3.97	0.997	Medium High
C16	I am afraid about the legal liability set for drone owners/operators.	3.64	1.113	Medium High
Overall Score				
Mean Score		4.292		
Standard Deviation		0.490		
Level		High		

3.4 Perception of Disclosure of Drone Applications

Table 5 shows the outcomes of the perception of drone application exposure among FKMP students. The results reveal that the perception was at a medium-high level, as indicated by a mean score of 3.83 and a standard deviation of 0.64. The item that garnered the highest mean score was item D8, which stated "Although drone technology provides many advantages, human involvement is still required." This item obtained a mean score of 4.56 and a standard deviation of 0.63. This high mean score is because 62.7% of respondents strongly agreed with the statement, followed by 32.4% who agreed, 4.1% who were unsure, 0.4% who disagreed, and 0.4% who strongly disagreed with the notion that human involvement is required about drones.

A similar trend was observed for item D9, which stated "drones require continuous surveillance by humans." This item obtained the second-highest mean score of 4.53 and a standard deviation of 0.67. Most respondents either agreed or strongly agreed with this statement, showing a strong inclination toward the belief that drones necessitate constant supervision by humans. On the other hand, the item with the lowest mean score was item D14, which obtained a mean score of 2.97 and a standard deviation of 1.55. Respondents were more likely to express uncertainty regarding the statement "I have the necessary knowledge to use this drone technology." The overall interpretation of the mean scores in this section indicates varying levels of perception, ranging from medium-low to medium-high and high levels. It is worth noting that there were certain items, namely D5 and D9, for which no respondents expressed strong disagreement (0%). These items focused on the use of drone technology in different fields and the requirement of constant human supervision for drones, respectively.

Table 5 *Descriptive analysis of exposure to the application of drone technology*

Item	Statement	Mean Score	Standard Deviation	Interpretation Mean Score
D1	Knowledge of drone technology helps improve engineering skills in learning related to my field.	4.48	0.837	High
D2	Drone technology makes learning related to my field easier.	4.17	1.066	High
D3	Exposure to drone technology in my field provides a comprehensive understanding of engineering science.	4.20	0.861	High
D4	The use of drone technology in my field involves various skills.	4.28	0.900	High
D5	The use of drone technology in my field involves a combination of various knowledge (Example: electrical, design, mechanical etc).	4.34	0.781	High
D6	Exposure to drone technology in my field is sufficient.	3.08	1.355	Medium High
D7	I think that drones are easy for students to operate.	4.07	0.989	High
D8	Although drone technology provides many advantages, human involvement is still required.	4.56	0.637	High
D9	Drones require constant human supervision.	4.53	0.671	High
D10	I think it's easy to learn to make drones.	3.61	1.347	Medium High
D11	I think drones will be easy to control/operate.	3.87	1.146	Medium High
D12	I find drone technology useful in an assignment of mine in the future.	4.48	0.719	High
D13	I have enough resources to use this drone technology.	3.01	1.417	Medium High
D14	I have the necessary knowledge to use this drone technology.	2.97	1.556	Medium Low
D15	I can complete this drone-related task if no one is around to tell me what to do.	3.17	1.478	Medium High
D16	I can complete this drone-related task if I am given a long period of time.	3.65	1.250	Medium High
D17	I can complete this drone-related task if I am given help from others.	3.90	1.091	Medium High
D18	My interaction with the drone system is clear and understandable.	3.22	1.318	Medium High
D19	Learning to operate this drone was easy for me.	3.56	1.179	Medium High
D20	It's easy for me to become good at using this drone.	3.49	1.252	Medium High
Overall Score				
Mean Score		3.832		
Standard Deviation		0.644		
Level		Medium High		

3.5 Discussion

The findings of the study show that FKMP UTHM students have a high level of understanding and positive perception towards drones. Respondents are comfortable with drone technology due to its widespread use in various fields. Additionally, drones have been widely accepted for their assistance in human tasks. This contradicts Petritoli et al., (2018) that the use of drones is fatalistic and lacks confidence. Public trust in drones has increased with technological advancements. The understanding of drones among FKMP students is not unfamiliar, as efforts in drone research and development have been implemented. The high perception of understanding of drone technology is seen across different disciplines among FKMP UTHM students. The production of drone technology involves communities from various fields. Despite positive responses, there are deficiencies in the consistency of technology acceptance among students. The country can benefit from the capabilities of drone technology to increase productivity and achieve its goals. Adapting the use of drones starts with ensuring a positive perception and understanding of this technology.

The investigation revealed that students have a high level of perception towards embracing drone technology in the realm of education. This finding is in line with Invernizzi et al., (2021) that demonstrates the positive impact of drones on motivation, satisfaction, and performance in both learning and teaching. Despite the widespread adoption of drones, safety apprehensions remain a significant factor. Climate/weather concerns during drone use are also prevalent, as suggested by Alawin et al., (2018). As affirmed by Yepes et al., (2022), pedagogical practices that involve the utilization of technology contribute to effective learning. This finding aligns with the high level of acceptance exhibited towards drones, which is fueled by a genuine interest and motivation to learn and explore drone technology. The integration of drones in both technical and theoretical learning has successfully enhanced students' curiosity and drive, as evidenced in a specific study.

The study's findings on the perception of drone application exposure among students are at a medium-high level. The field of engineering faces challenges in education due to the combination of formal instruction and outdoor activities. Formal exposure to drones is moderately high, particularly through projects conducted outside of the classroom. These outdoor projects provide a more comprehensive understanding through demonstrations and problem-solving exercises. Interaction and practical application of skills further enhance understanding and memory retention. Institutions actively encourage external projects and students often require assistance from external parties for tasks related to drones. The sources and knowledge provided are of a medium to high level. Effective instruction and access to technological resources significantly impact learning outcomes. Exposure to drone technology can enhance engineering skills and problem-solving abilities. The utilization of drones within a problem-solving framework can optimize the learning process. Overall, exposure to drones can contribute to an improved learning experience in the classroom.

4. Conclusion

The study concludes that the understanding of drones is at a high level due to their widespread use in various fields. While concerns about data privacy and legal liability persist, the adoption of drone technology in learning is still accepted due to the interest and motivation in improving engineering knowledge. Furthermore, the study's findings indicate that the level of perception regarding drone application exposure is moderate to high. Researchers concluded that drone exposure varied among different engineering curricula, with Aeronautical Engineering students showing higher levels of exposure due to their direct engagement with drone production and instruction from experienced lecturers. However, the Mechanical Engineering, Mechanical Technology, and Manufacturing Engineering departments provided comparable levels of exposure to drone technology through subject control structures, designs, and automated systems. Researchers suggest future studies could include other programmes that have taught the necessary courses for drone technology development. This study can use a qualitative or quantitative-qualitative approach to examine the perceptions of lecturers skilled in drones. An experimental study can compare groups engaged in learning using drones and groups without drones. The researcher suggests studying the phenomena occurring within the sample of relationships between variables of drone understanding, drone technology acceptance, and exposure to drone application.

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