International Journal of Innovative Research and Scientific Studies, 8(3) 2025, pages: 3344-3355

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Artificial Intelligence tools perceptions: A survey to measure the Perceptions of Engineering Students

Ala'a M. Al-Falahat

Department of Mechanical Engineering, Faculty of Engineering, Mutah University, Al-Karak 61710, Jordan.

(*Email: alaa.falahat@mutah.edu.jo*)

Abstract

This research intends to evaluate the usage and impact of Artificial Intelligence (AI) in engineering education through a cross-sectional study using a web-based questionnaire distributed to 290 undergraduate and graduate students. The objective is to assess the students' perceptions toward AI tools, which AI uses in their education and future jobs, its prospects and challenges, and their experiences with AI applications. The results indicated high acceptance of general-purpose AI applications in engineering, such as ChatGPT (50.7% regular use) and Grammarly (65.9%), while lower acceptance exists for specialized AI applications in engineering. Students see the use of AI as beneficial for improving academic performance, especially in writing technical reports (94.1% agreement) and research (86.6% agreement). The study found that 87.6% of students agreed that AI gives them an edge in courses and projects. However, 65.5% of the respondents were concerned about ethics and felt traditional skills in problem-solving should be upheld. Attitudes toward AI tools and the way they are used showed statistically significant differences across academic levels and years in the program, pointing toward the necessity of tailored teaching methods. While underlining the transformative potential of AI in engineering education, the study emphasizes the need to address ethical considerations and find a middle ground between promoting AI-assisted learning and developing traditional skill sets.

Keywords: AI tools, Artificial intelligence AI, Attitudes towards AI's, Engineering.

DOI: 10.53894/ijirss.v8i3.7242
Funding: This study received no specific financial support.
History: Received: 19 March 2025 / **Revised:** 23 April 2025 / **Accepted:** 25 April 2025 / **Published:** 21 May 2025

Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.
Transparency: The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Publisher: Innovative Research Publishing

1. Introduction

AI transforms engineering education by challenging established conventions in learning and providing students with the skills that the workforce of modern-day demands [1, 2]. Advancements in AI technologies, combined with their incorporation into the engineering curriculum, enhance the educational ecosystem by rendering it more interactive, individualized, and in alignment with industry requirements [3]. AI practices in teaching include machine learning algorithms for certain tasks, virtual simulations employing simulations, and intelligent tutoring systems [4-6]. This has helped to increase the level of student engagement and greater learning outcomes [7-10]. These technologies also help develop critical thinking and problem-solving skills to prepare students for a world that is increasingly going to be automation and data-driven [11-15]. As engineering education develops, the implementation of AI will be instrumental in determining how the learning landscape and professional development unfold [16]. Thus, AI's significance in learning is now going far beyond just improving conventional techniques. AI will pave the way to developing critical skills in problem-solving, data analysis, and predictive modeling, which are indispensable skills in today's engineering setting [17-19]. This enhances the students' understanding of complex engineering principles while preparing them for the adaptation to rapidly changing technologies in their professions.

With advancements in AI being integrated into various industrial processes and productivity enhancement, the demand for engineers well-versed in AI technologies has increasingly become vital [20, 21]. Integrating AI into engineering education is, therefore, not just a passing trend but also an absolute necessity in fulfilling industry demands. It is creating a pathway for the next generation of engineers who understand AI and will also utilize it for future innovations. Engineering programs are now being modified to ensure that graduates are not only aware of the technologies being adopted by the industry but are also adept at applying them in industry practice for applications such as predictive maintenance, quality control, and product design. This transformation of education is bridging the ever-widening chasm between academia and industry and producing engineers capable of applying AI to make productivity gains, improve efficiency, and usher in new technological advancements in their discipline [22-26]. The rising presence of AI within engineering education, therefore, reflects a wider effort at equipping the next generation of engineers with the input and the requisite competencies to operate in a fast-evolving technological environment.

Since quickly emerging technological developments for AI tools have affected several careers, engineering education is among them. With an increase in students' interactions with AI tools, understanding their perceptions is critical for educators and policymakers. A recent survey [27-30] highlights the fact that engineering students have a high level of interest in AI tools but worry about becoming too dependent on these technologies. Likewise, Ali et al. [31] found that AI tools help with problem-solving skills but can obstruct creativity in certain engineering tasks [32].

The insertion of AI tools and techniques into engineering curricula is actively changing the way that future engineers are educated so that the training imparted in academia matches the fast-moving technological developments of the industry [33, 34]. Against the backdrop of automation, robotics, and advanced manufacturing, AI in innovation and engineering syllabuses is believed to be required to be integrated to meet the current workforce expectations of students [33, 35-37]. This change helps to modify the traditional engineering education model away from teaching basic skills towards a model that emphasizes cutting-edge skills in data analysis, predictive modeling, and intelligent system design. AI tools like machine learning algorithms, generative design software, and simulation platforms contribute significantly to experiential learning—the hands-on engagement of students with real-life engineering problems. The options such tools provide for students to understand complex systems, optimize designs, and simulate performance under multiple conditions often yield insights otherwise overlooked by conventional approaches. Furthermore, AI in the education of engineers promotes critical thinking, innovation, and problem-solving skills, which are fundamental in solving modern engineering challenges [38].

Now, while there are many promising AI tools in education, there are also many limitations to this engineering. The ethical issues are of great importance and relate to the bias of AI algorithms that may reinforce existing inequalities in educational content and assessment [39]. Transparency is an essential characteristic of AI because it allows a reasonable assessment of whether an outcome is fair and accurate at all, which is particularly challenging in educational settings due to the AI decision-making processes [40].

In addition to the present impediment, particularly in terms of information privacy and security, as AI tool systems require access to a large amount of student data, there is a technical restriction [41]. The current data-intensive techniques not only raise privacy concerns but also create uncertainty about the reliance on engineering and may reduce the essential human exchanges within the education system [42, 43].

From a pedagogical point of view, AI tools are often limited in their ability to provide truly personalized learning experiences and adequately respond to the various needs and learning styles of human students [35, 44, 45]. Moreover, there is concern that AI-driven tuition may unknowingly stifle innovation by offering predefined solutions, possibly restricting students' ability to refine original thinking and problem-solving skills [46]. Such a restriction underlines the need for a balanced approach to the integration of AI into the study of individuals who use the advantages of AI during energetically solving their deficiencies in order to provide a robust and equitable learning environment.

The main objective of the study is to find out and understand how engineering students perceive the use and influence of AI tools in their education and their future professional careers. As AI tools like ChatGPT, MATLAB AI Toolbox, Mathy, AnsysSimAI, Grammarly generative design software, and AI-powered simulation instruments are increasingly integrated into engineering education and the field, it is essential to measure students' awareness, use, and attitudes towards the aforementioned systems.

The study aims to achieve several key objectives.

1. Assess Familiarity and Usage: The measure of familiarity and use seeks to establish the means by which familiar engineering students are integrated with AI tools and the extent to which they apply such technologies in their college projects. The present invention aims to determine which AI tools they are normally familiar with and for which purposes, similar to design optimization, information analysis, or knowledge acquisition.

2. Evaluate perceived Impact on Learning and Performance: Assessing the discerned effect on education and performance. Another key objective shall be to assess how students perceive the impact of generative AI tools on their learning events and their learning performance. This includes checking whether students believe that AI enhances their

understanding of the engineering concepts involved, improves the quality of their work, or, alternatively, helps them to solve their problems more effectively.

3. Identify Benefits and Concerns: Identify rewards and challenges, to identify at the same time the observed aid and capability problems linked to the use of AI tools. The rewards might include increased productivity, creativity, and access to sophisticated replicant abilities, while the concerns might include issues such as overreliance on AI tools, data segregation, or perhaps the ethical consequences of using AI tools in a scientific context.

4. Explore Ethical and Educational Implications: examine virtuous and enlightening effects the investigation furthermore aims to investigate students' views on the ethical factors of using AI tools in academia, similar to academic integrity, plagiarism, and the need for guidelines, etc. Also, it seeks to find out how AI implementations should be integrated into the engineering course of study in order to prepare students for their future careers in a better way.

2. Methodology and Framework

The methodology of this survey shall be developed so that the views of both undergraduate and postgraduate engineering students on the use and effect of AI tools in their education are systematically captured and analyzed. The structured questionnaire method provides a solid outline for gathering the perceptions of technological students using AI tools. In order to give a broad overview of the way AI is observed and used in education and ultimately to inform future development plans and study paths in engineering learning, the inspection targets use a combination of quantitative and qualitative questions.

2.1. Study Instrument

The online distribution of the cross-sectional web questionnaire was easy. This method uses online surveys because they're cheap, fast, and flexible. A community Jordanian university distributed the questionnaire online to students in an engineering department. From 1 October to 30 November 2024, the selection of information was extended. Google Structures Platform, an open-source data collection tool, was used. All undergraduate and graduate students are eligible to participate (random sample). Attendees were aware that all individual data collected, such as the labels and the university identification numbers, would be de-identified so that they could not be identified in the printed study. Furthermore, it was confirmed that their statistics would be used only for investigative purposes.

2.2. Questionnaire

The quantitative questionnaire consists of 13 questions related to the use of AI in engineering. It focuses on the study of students' viewpoints and their behavioral goals related to the use of AI support to provide personalized content for students. The student is also asked about the risks encountered when using AI in higher education. The student was contacted by Google and asked if they would be willing to assist in filling out the questionnaire.

The students were requested to return their complete questionnaires within one week, that is, before the end of October 2024. In total, 381 questionnaires were sent out, and 290 complete forms were returned and included in this study. Students completed the survey in an average of 7 to 10 minutes. The supervisor verified the concerns based on the same survey published in the text.

2.3. Data Analysis Plan

Equally descriptive and inferential statistical procedures using the Statistical Package for the Social Sciences (SPSS) software are employed in the examination of compiled data. Descriptive statistics were utilized to address the general prevalence and form of AI tool use among students in engineering education and the general attitude towards AI tools in the context of students in engineering education by summarizing the disparity in responses to AI implementation use and outlook on (Attitude towards) AI tools. The chi-square test is used to assess the difference in academic level and years in the program regarding the use and attitudes toward AI implementations in an engineering education environment, complemented by Cramer's V as a nonparametric effect size measure and post hoc analysis of correct standardized residuals (r). These tests were suitable since they matched the categorical and ordinal nature of our variables, which did not require us to meet the condition of normality.

3. Data Analysis

Purposive sampling was used as a sampling method in the present study. The study received responses from 290 students participating in various engineering disciplines. The researchers selected contributors based on exact standards to ensure that the sample represents a wide range of university students (Graduate and Undergraduate). Purposive sampling enabled the researchers to target individuals who could provide invaluable perceptions for the purposes of the study, including the attitudes of students towards AI, measuring their readiness for AI integration, and examining the advantages and disadvantages associated with AI tools in an engineering context. Therefore, Table 1 provides details of the student population in terms of educational level and program years. This provides insight into the dispersion of students within these categories, which may be valuable in terms of understanding the views of the student body and possibly in terms of supply distribution or perhaps in terms of program organization.

Table 1.
Demographic category of the students participating.

Category		Counts	Percentage (%)
Academic Level	Undergraduate	172	59.31
	Graduate	118	40.69
Years in program	Less than 1 year	32	11.03
	1-2 years	124	42.76
	3-4 years	80	27.59
	More than 4 years	54	18.62

Academic Level: The survey includes participants from two major academic levels: undergraduate 59.31% of the respondents identified as undergraduate, while 40.69% were graduate (Master's and PhD degrees), a strong representation of students presently pursuing their bachelor's degrees. The current paper provides a complete picture of the nature of generative AI's role at several stages of education.

Years in Program: In comparison with one academic year, 11.03% of respondents were in their current program for less than one academic year; primarily, respondents (42.76%) reported 1-2 years. In addition, respondents (27.59%) and (18.62%) reported 3-4 years and more than four years, respectively, within their academic journey and likely to have experienced a variety of AI tools.

Furthermore, Table 2 gives details about the familiarity and use of the various AI tools among the assessed respondents. ChatGPT seems to be the most commonly used AI tool among respondents, with a 50.7% coverage of those who are familiar with it and use it regularly. The present high incorporation assessment indicates that ChatGPT has developed into a sought-after and accessible AI tool for students in engineering programs. The MATLAB AI Toolbox shows a further split usage form, which is used by 29% of respondents regularly but is unfamiliar to nearly half (49%). The present may suggest that the MATLAB AI Toolbox should be more dedicated and may be used more frequently in some areas of research and advanced courses.

Table 2.
Analysis of students' usage of the most widely AI tools.

AI Tools	Familiar but regularly use it	Familiar but rarely use it	Familiar but never used it	Unfamiliar
ChatGPT	147 (50.7%)	84 (29.0%)	48 (16.6%)	11 (3.8%)
MATLAB AI Toolbox	84 (29.0%)	23 (7.9%)	41 (14.1%)	142 (49.0%)
Mathy	109 (37.6%)	132 (45.5%)	25 (8.6%)	24 (8.3%)
Ansys SimAI	40 (13.8%)	14 (4.8%)	7 (2.4%)	229 (79.0%)
Grammarly	191 (65.9%)	39 (13.4%)	25 (8.6%)	35 (12.1%)

Mathy and Ansys SimAI show low levels of normal usage and higher levels of unfamiliarity. Mathy, in fact, has a higher percentage (45.5%) of respondents who are familiar with it but rarely employ it, arguing that, as many are aware of it, it could not remain indispensable in their current work. Ansys SimAI has a high unfamiliarity score of 79%, stating that it may be a more specialized tool or not too widely integrated into the learning process. Interestingly, Grammarly, which is neither unique to engineering implementation, has a high regular usage rate after ChatGPT (65.9%). The current data shows that students recognize the value of writing and exchanging skills in their studies, even in a technical field.

The above usage form includes the change in the rate of the use of AI tools in engineering education. While general-purpose applications, such as ChatGPT and Grammarly, see widespread use, other focused engineering AI tools have low adoption rates. This could reveal the prospect of teaching activities to introduce and integrate the aforementioned specific AI tools more effectively into their studies, perhaps leading to better student orientation towards the application of AI in engineering.

Table 3.
Analysis of students' Attitude AI tools in education.

AI Attitude	Agree	Don't Know	Disagree
Purposes Usage AI Tools in Engineering			
Design and simulation	210 (72.4%)	54 (18.6%)	26 (9.0%)
Writing technical reports	273 (94.1%)	10 (3.4%)	7 (2.4%)
Coding and debugging	206 (71.0%)	70 (24.1%)	14 (4.8%)
Research and literature review	251 (86.6%)	19 (6.6%)	20 (6.9%)
Idea generation for projects	147 (50.7%)	92 (31.7%)	51 (17.6%)
Perceptions of AI's Impact			
Enhance my understanding of complex engineering concepts	201 (69.3%)	65 (22.4%)	24 (8.3%)
AI improves the quality and efficiency of my design and simulation tasks	196 (67.6%)	64 (22.1%)	30 (10.3%)
Using AI helps me stay ahead in my coursework and projects	254 (87.6%)	20 (6.9%)	16 (5.5%)
Concerns and Ethical Considerations			
Ethical concerns like plagiarism or data security	190 (65.5%)	65 (22.4%)	35 (12.1%)
Dependency on AI over traditional problem-solving skills	170 (58.6%)	65 (22.4%)	55 (19.0%)
Accuracy and reliability of AI-generated outputs	77 (26.6%)	186 (64.1%)	27 (9.3%)

The analysis of the attitudes towards AI tools in engineering, as shown in Table 3, reveals where AI is most widespread and where there is additional concerns or uncertainties, as following section

Purposes of AI Tool Usage in Engineering: facts reveal the strong conviction about the use of AI tools in the field of engineering. Writing technical reports, which has a high consensus value of 94.1%, declares the widespread use of AI tools in documentation tasks. Design and simulation, as well as coding and debugging, show high levels of mutual agreement, i.e., 72.4% and 71.0%, respectively, suggesting that AI tools are of value to the technological undertaking concerned. There is also an increase in agreement between the research and literature assessments of 86.6%, highlighting the task of AI to gather and investigate details. Still, idea generation for projects shows a low agreement measure of 50.7%, with a significant 31.7% uncertainty, implying that while AI is acceptable for structured projects, there is tomorrow's extra hesitation in using it for creative processes. The present form implies that engineering professionals and students are more comfortable using AI in well-defined, analytic tasks rather than open-ended, creative ones.

Perceptions of AI's Impact: Statistics on the impact of AI on the understanding of the consequences of AI on engineering show that there is a positive mentality. A large majority (87.6%) agree that using AI helps people stay ahead of their coursework and projects, expressing their strong belief in the capability of AI to improve educational and skilled performance. The present also has considerable harmony (69.3%) that AI enhances the understanding of complex engineering concepts. Similarly, 67.6 percent agree that AI tools improve the quality and efficiency of design and model projects in order to determine the potential of AI to maximize technical processes. The above-mentioned higher agreement rates are attributed to various characteristics, resulting in the perception by engineering students and professionals of AI as a powerful tool capable of significantly improving their education, productivity, and the quality of their work. The relatively low disagreement rates (ranging from 5.5% to 10.3%) further reinforce this constructive understanding, although the presence of a few uncertainties (ranging from 6.9% to 22.4%) indicates that there is still room for further learning and exposure to the abilities and limitations of AI in the field.

Concerns and Ethical Considerations: The data on concerns and ethical elements related to AI tools in engineering reveal diverse views. A significant 65.5% of respondents admit that ethical concerns, including issues such as plagiarism and data security, have been acknowledged, indicating a widespread awareness of the dangers of using AI. Similarly, 58.6% express concern about dependency on AI over traditional problem-solving skills. Interestingly, even though the accuracy and reliability of AI-generated results are apparent, only 26.6% agree that the present is of interest, while a substantial 64% are unsure. This higher degree of uncertainty may indicate a need for clear insight or expertise in addition to the limitations of AI to produce precise and reliable results. The relatively minimal disagreement rates among these concerns (ranging between 9.3% and 19.0%) suggest that primarily respondents either acknowledge these concerns or are uncertain about them, rather than dismissing them outright. These results show that AI is not only used in academic writing for its capabilities but also for its ethical implications, potential hazards, and the importance of maintaining critical reflections and traditional engineering technological talents in the field of AI adoption.

However, Table 4 provides information about the statistical significance of the differences in usage patterns between undergraduate and graduate students.

Table 4.
Chi-Square corrected standardized residuals for AI tools used by academic-level.

AI tools familiarity and usage	Chi-square (χ^2) (df=3)	P-value	Cramer's V	Corrected standard residuals (r)				
				Academic Level	Familiar but regularly use it	Familiar but rarely use it	Familiar but never used it	Unfamiliar
ChatGPT	138.828	<0.001	0.074	Undergraduate	-1.001	0.311	0.492	0.924
				Graduate	1.001	-0.311	-0.492	-0.924
MATLAB AI Toolbox	115.931	<0.001	0.084	Undergraduate	-0.743	-0.726	-0.452	1.382
				Graduate	0.743	0.726	0.452	-1.382
Mathy	130.772	<0.001	0.116	Undergraduate	0.087	-1.270	1.777	0.332
				Graduate	-0.087	1.270	-1.777	-0.332
Ansys SimAI	458.772	<0.001	0.099	Undergraduate	0.096	-0.169	-1.676	0.639
				Graduate	-0.096	0.169	1.676	-0.639
Grammarly	259.683	<0.001	0.209	Undergraduate	2.702	-2.148	0.925	-2.480
				Graduate	-2.702	2.148	-0.925	2.480

In a statistical study on the use of AI tools in engineering learning, three key metrics and their corresponding thresholds are considered. For Chi-square values (df=3) when P-values ($P < 0.01$), it is interpreted that $\chi^2 > 7.815$ is statistically significant, $\chi^2 > 11.345$ is highly significant, and $\chi^2 > 16.266$ is very highly significant. Cramer's v standards indicate the strength of association: < 0.1 suggests negligible association, 0.1 to < 0.3 indicates weak association, 0.3 to < 0.5 indicates moderate association, and ≥ 0.5 indicates strong association. For corrected standard residuals, $|r| < 2$ indicates no significant difference, while $|r| \geq 2$ proposes an imperative contrast between the ascertained and the expected frequency.

The study on the use of AI tools in engineering education, as displayed in Table 4, shows useful differences that are close to being a real effect or relationship present in the data through education stages, with change strengths of association revealing a very useful difference for all tools ($p < 0.001$), together with principles ranging from 115.931 (MATLAB Artificial Intelligence Toolbox) to 458.772 (Ansys SimAI). The strength of this association, measured by Cramer's v, ranges from negligible to weak, with standards of 0.074 for ChatGPT and 0.209 for Grammarly. In particular, AI tools show negligible association between academic level and tool usage: ChatGPT (Cramer v = 0.074), MATLAB AI Toolbox (0.084), and Ansys SimAI (0.099) all possess Cramer's v standards below 0.1, revealing negligible association. Mathy and Grammarly have weak associations, with values between 0.1 and 0.3.

Correct standard residual analysis reveals exact patterns, specifically for Grammarly, with standards of 2.702, -2.148, and -2.480 for undergraduate students and -2.702, 2.148, and 2.480 for graduates.

To sum up, while all AI tools show statistically significant differences in usage form across academic levels, the meaning of this difference varies, with Grammarly standing out as the main difference in use among the academic levels.

Table 5.
Chi-Square corrected standardized residuals for Attitudes towards Al tools by academic level.

Attitudes towards Al tools	Chi-square (χ^2) (df=3)	P-value	Cramer's V	Corrected standard residuals r			
				Academic Level	Agree	Disagree	Don't Know
Design and simulation	203.366	<0.001	0.072	Graduate	0.950	0.176	-1.220
				Undergraduate	-0.950	-0.176	1.220
Writing technical reports	482.531	<0.001	0.125	Graduate	-0.042	1.676	-1.355
				Undergraduate	0.042	-1.676	1.355
Coding and debugging	201.710	<0.001	0.050	Graduate	0.838	-0.388	-0.694
				Undergraduate	-0.838	0.388	0.694
Research and literature review	369.607	<0.001	0.135	Graduate	-2.148	0.878	2.062
				Undergraduate	2.148	-0.878	-2.062
Idea generation for projects	48.007	<0.001	0.025	Graduate	-0.195	-0.236	0.402
				Undergraduate	0.195	0.236	-0.402
Enhance my understanding of complex engineering concepts	177.607	<0.001	0.190	Graduate	-2.796	2.705	1.305
				Undergraduate	2.796	-2.705	-1.305
AI improves the quality and efficiency of my design and simulation tasks	159.090	<0.001	0.051	Graduate	0.319	-0.866	0.276
				Undergraduate	-0.319	0.866	-0.276
Using AI helps me stay ahead in my coursework and projects	384.193	<0.001	0.081	Graduate	-0.490	1.303	-0.537
				Undergraduate	0.490	-1.303	0.537
Increased efficiency in completing tasks	139.828	<0.001	0.042	Graduate	-0.581	0.645	0.158
				Undergraduate	0.581	-0.645	-0.158
Enhanced creativity and problem-solving abilities	83.966	<0.001	0.025	Graduate	0.201	0.189	-0.415
				Undergraduate	-0.201	-0.189	0.415
Streamlined design and manufacturing processes	136.766	<0.001	0.073	Graduate	-0.090	1.240	-0.669
				Undergraduate	0.090	-1.240	0.669

The evaluation of the chi-square data from Table 5 was carried out, revealing a significant difference in attitude toward the use of AI tools between graduate and undergraduate students. As shown by the chi-square statistics, there is a significant difference in attitude towards AI tools in engineering knowledge between graduate and undergraduate students. Graduate students present more useful beliefs about AI tools for design and simulation ($\chi^2 = 203.37$, $p < 0.001$, $V = 0.0716$) and coding and debugging ($\chi^2 = 201.71$, $p < 0.001$, $V = 0.0716$), alongside correct standard residuals indicating a higher likelihood of agreement (0.9499) compared to undergraduates. Alternatively, undergraduates show more helpful attitudes toward AI enhancing their understanding of complex technological principles ($\chi^2 = 177.61$, $p < 0.001$, $V = 0.1896$), together with a correct standard remainder of 2.7956 indicating a higher probability of agreement.

Both groups have similar views of AI tools for idea generation ($\chi^2 = 48.01$, $p < 0.001$, $V = 0.0246$) and improving creativity and problem-solving abilities ($\chi^2 = 83.97$, $p < 0.001$, $V = 0.0249$), with a low difference detected. Nevertheless, graduate students frequently turn out to be more critical of AI in writing technical reports ($\chi^2 = 482.53$, $p < 0.001$, $V = 0.1248$) and streamlining design and manufacturing processes ($\chi^2 = 136.77$, $p < 0.001$, $V = 0.0733$), as demonstrated by higher disagreement residuals (r) (1.6759 and 1.2398, respectively).

In undergraduate students, uncertainty in a number of AI applications is often high, and they propose a need for increased exposure and education on AI tools during their studies. The conclusions underline the importance of personalized teaching methods to address the divergent views and needs of both graduate and undergraduate students, ensuring the productive integration of AI tools into engineering knowledge.

Table 6.
Chi-Square corrected standardized residuals for AI tools used by Years in Program.

AI tools familiarity and usage	Chi-square (df=3)	P-value	Cramer's V	Corrected standard residuals r				
				Years in Program	**Familiar but regularly use it**	**Familiar but rarely use it**	**Familiar but never used it**	**Unfamiliar**
ChatGPT	138.828	<0.001	0.074	1-2 years	0.747	-0.240	-0.167	-1.058
				3-4 years	-1.196	0.240	0.975	0.664
				Less than 1 year	0.667	-0.524	-0.150	-0.210
				More than 4 years	-0.112	0.452	-0.787	0.752
MATLAB AI Toolbox	115.931	<0.001	0.084	1-2 years	1.068	-0.367	0.500	-1.120
				3-4 years	-0.919	-0.654	-0.494	1.532
				Less than 1 year	-0.111	1.014	0.256	-0.626
				More than 4 years	-0.213	0.400	-0.275	0.169
Mathy	130.772	<0.001	0.116	1-2 years	0.586	0.610	-1.137	-0.975
				3-4 years	-0.561	-0.373	1.453	0.181
				Less than 1 year	-0.398	0.164	0.161	0.239
				More than 4 years	0.219	-0.478	-0.352	0.838
Ansys SimAI	458.772	<0.001	0.099	1-2 years	-0.380	-1.100	1.552	0.315
				3-4 years	-0.013	1.310	0.059	-0.700
				Less than 1 year	0.319	1.272	-0.943	-0.584
				More than 4 years	0.241	-1.131	-1.281	0.873
Grammarly	259.683	<0.001	0.209	1-2 years	-2.170	1.504	-0.292	1.834
				3-4 years	1.748	-0.292	0.985	-3.087
				Less than 1 year	-1.611	-1.265	0.161	3.531
				More than 4 years	2.047	-0.558	-0.890	-1.629

The study of attitudes towards AI tools based on the chi-square statistics of Table 6 reveals a significant difference over a different duration in the program. The chi-square value of 138.83 ($p < 0.001$, Cramer's V = 0.0739) indicates a strong association with the years of the progrem. Students with 1-2 years in program are also expected to consistently use ChatGPT (r = 0.7466), while those more than 4 years in program are additionally expected to be unfamiliar (r = 0.7515). MATLAB AI Toolbox has a chi-square value of 115.93 ($p < 0.001$, Cramer's V = 0.0836), together with students in their first 1-2 years more prone to frequently employ it (r = 1.0683), whereas those with 3-4 years are more prone to be unfamiliar (r = 1.5316). Mathy, with a chi-square value of 130.77 ($p < 0.001$, Cramer's V = 0.1155), are more frequently familiar used by students in their first 1-2 years (r = 0.5865), while that with further compared to 4 years shows increased unfamiliarity (r = 0.8383). Ansys SimAI, together with a chi-square value of 458.77 ($p < 0.001$, Cramer's V = 0.0993), is more familiar to students with 3-4 years, while they are less familiar with more than 4 years. Moreover, together with a chi-square value of 259.68 ($p < 0.001$, Cramer's V = 0.2091), be excessively utilized by students alongside additional instead of 4 years (r = 2.0470), as those alongside less rather than 1 year show greater unfamiliarity (r= 3.5313).

These findings suggest that the familiarity and use of AI tools changes with the period of the program, highlighting the need for targeted teaching methods to improve the integration of AI utensils at different levels of academic development.

Table 7.
Chi-Square corrected standardized residuals for attitude towards AI tools used by years in the program.

Attitudes towards Al tools	Chi-square (df=2)	P-value	Cramer's V	Corrected standard residuals r			
				Years in Program	Agree	Disagree	Don't Know
Design and simulation	203.366	<0.001	0.072	1-2 years	1.64836	-1.710605	-0.637168
				3-4 years	1.155566	0.380598	1.047452
				Less than 1 year	1.330293	2.710081	-0.461537
				More than 4 years	0.302597	-0.44427	-0.02138
Writing technical reports	482.531	<0.001	0.125	1-2 years	1.651721	0.005334	-2.130977
				3-4 years	0.732862	-0.797014	1.613908
				Less than 1 year	1.694685	2.720223	-0.106257
				More than 4 years	0.106287	-1.281137	0.940765
Coding and debugging	201.710	<0.001	0.050	1-2 years	1.286709	-0.546112	-1.090382
				3-4 years	0.819002	1.310441	0.211745
				Less than 1 year	1.128408	-0.476379	1.434754
				More than 4 years	0.213298	-0.42711	-0.012156
Research and literature review	369.607	<0.001	0.135	1-2 years	-1.504397	0.209981	1.859255
				3-4 years	2.602743	-1.30518	-2.252102
				Less than 1 year	-1.48133	1.326235	0.684312
				More than 4 years	0.115875	0.164225	-0.327951
Idea generation for projects	48.007	<0.001	0.025	1-2 years	-1.390097	0.060206	1.444045
				3-4 years	0.380598	1.011531	-1.236293
				Less than 1 year	1.041892	-0.801258	-0.463804
				More than 4 years	0.49109	-0.592996	-0.042472
Enhance my understanding of complex engineering concepts	177.607	<0.001	0.190	1-2 years	-0.757877	-0.112902	0.912786
				3-4 years	1.011786	-1.249717	-0.293333
				Less than 1 year	0.333502	2.279995	-1.875217
				More than 4 years	-0.466932	-0.256767	0.686058
AI improves the quality and efficiency of my design and simulation tasks	159.090	<0.001	0.051	1-2 years	-1.472598	0.067198	1.612657
				3-4 years	-1.422885	0.312404	1.376483
				Less than 1 year	1.350396	-0.190989	-1.383831
				More than 4 years	2.418316	-0.290367	-2.516129
Using AI helps me stay ahead in my coursework and projects	384.193	<0.001	0.081	1-2 years	0.501473	0.082463	-0.726858
				3-4 years	0.370971	-0.238117	-0.268188
				Less than 1 year	-1.152453	1.013356	0.586604
				More than 4 years	-0.135668	-0.647037	0.759541
Increased efficiency in completing tasks	139.828	<0.001	0.042	1-2 years	0.688886	-1.444867	0.343522
				3-4 years	-0.667215	0.945691	0.021728
				Less than 1 year	-0.380711	1.22999	-0.526921
				More than 4 years	0.196989	-0.239515	-0.037421
Enhanced creativity and problem-solving abilities	83.966	<0.001	0.025	1-2 years	0.074793	0.146166	-0.225743
				3-4 years	0.027596	-1.398345	1.281972

				Less than 1 year	0.852928	-0.032971	-0.976353
				More than 4 years	-0.813246	1.446297	-0.399161
Streamlined design and manufacturing processes	136.766	<0.001	0.073	1-2 years	0.02039	1.002892	-0.626408
				3-4 years	0.2257	-0.654838	0.18893
				Less than 1 year	-0.210737	-0.631645	0.576746
				More than 4 years	-0.115435	-0.014321	0.114968

The evaluation of attitude towards AI using chi-square information in Table 7 reveals a significant difference established over the years in the program. The chi-square value of 203. ($p < 0.001$, Cramer's V = 0.0716) shows a strong association with years in the program, together with students in their primary 1-2 years extra expected to agree (r = 1.6484). Writing technical reports tools reveal a chi-square value of 482.53 ($p < 0.001$, Cramer's V = 0.1248), together a with students less than 1 year expected to disagree (r = 2.7101). The code and debug tools have a chi-square value of 201.71 ($p < 0.001$, Cramer's V = 0.0716), with students expected to be more likely agree in their first 1-2 level (r = 1.6484). Research and literature review tools reveals the chi-square value of 369.61 ($p < 0.001$, Cramer's V = 0.1354), with students in their first 1-2 years is more likely to agree (r = 1.6484). Idea generation for project tools have a chi-square value of 48.01 ($p < 0.001$, Cramer's V = 0.0246), with minimal difference detection. A chi-square value of 177.61 ($p < 0.001$, Cramer's V = 0.1896), with students in their initial 1-2 years expected to agree (r = 1.6484).

Now the overall findings suggest that attitudes toward AI tools change substantially during the duration of the program, highlighting the need for targeted educational schemes to increase the integration of AI tools at different levels of academic progress.

At present, the overall results of the current analysis show that students have portrayed a high adoption estimate for general-purpose AI tools, with ChatGPT and Grammarly, which are commonly used by 50.7% and 65.9% of students, respectively. Compared to this, low adoption rates have been observed for focusing on engineering AI tools. There are considerable advantages of AI in terms of improving academic performance, with 94.1% of students agreeing on its value in writing a technical report and 86.6% in the supervision of analysis. Furthermore, 87.6% of students believe that AI helps those who remain ahead in coursework and projects. However, ethical concerns arise, with 65.5% of respondents admitting the need to maintain their traditional problem-solving skills, suggesting a desire for a balanced strategy to integrate AI.

The analysis also draws attention to the statistically significant differences between the use of AI tools and attitudes toward them during the collegiate years and throughout the program, and suggests the need to develop personalized teaching plans. The current study underlines the innovative capacity of AI tools in engineering performance while emphasizing the importance of resolving ethical issues and maintaining a standard in the context of AI-assisted training and traditional skills development. This outline provides a framework for a detailed examination of the use form of the AI device discussed earlier, demonstrating that the way exploration is not used exclusively in academic writing on the examined use form but also in the interpretations of research students and ethical issues concerning AI in engineering education.

4. Conclusions and Limitations

The study survey of 290 engineering students found that general-purpose AI tools such as ChatGPT and Grammarly, with a regular usage rate of 50.7% and 65.9% respectively, have strong credibility. This indicates a significant integration of these tools into students' study routines. Still, low adoption rates, together with a 29.9% and 79.9% unfamiliarity, are observed in specific engineering AI tools, such as the MATLAB AI Toolbox and Ansys SimAI. The present study suggests a gap in their integration into the study program, with the need for increased exposure and education on these particular tools.

Students viewed AI as a means of improving academic performance, particularly in projects such as writing a technical report (94.1% agreement) and conducting research (86.6%). Nevertheless, there was too much hesitation when using AI for creative projects to benefit from idea generation, with only 50.7 percent agreement and 31.7 percent uncertainty. This implies a preference for AI in well-defined analytical works over creative projects. Furthermore, 87.6% of students agreed that AI helps them stay ahead in their studies and activities, expressing their understanding of its usefulness for academic success.

Although there are positive beliefs regarding the exploration of fundamental ethical issues and the need to maintain traditional problem-solving skills, 65.5% of respondents admitted to facing these challenges. There was also a significant difference in the use and attitudes towards AI tools among students and graduates, possibly varying across different years of the initiative. The chi-square study found statistically significant differences between Cramer's V standards of 0.0246 and 0.2091, suggesting the need for an educational strategy approach in order to cope with changing demands and perspectives.

The study's reliance on self-reported information and its priority on a limited number of AI tools may hinder the generalizability of its own discoveries. The purposive sampling method used may not completely represent the broad range of engineering students, and the specific academic environment may limit the applicability of the results to the professional context. Future research should explore the elements facilitating differences in the use of AI tools at academic levels and the capabilities of emerging AI tools in engineering education.

In conclusion, while the study provides impressive results on the integration of AI into engineering guidance, it also highlights areas for improvement in the conception of study plans and the methods of integrating AI into practice. To maximize the benefits of AI as a means of promoting harmony with conventional skills, it will continue to be essential to solve these obstacles and to develop methods for properly integrating AI into all levels of education.

References

[1] T. Balart and K. J. Shryock, "A framework for integrating ai into engineering education, empowering human-centered approach for industry 5.0," presented at the 2024 IEEE Global Engineering Education Conference (EDUCON), 8-11 May 2024, 2024.

[2] J.-L. Martel, R. Arsenault, and F. Brissette, "Artificial intelligence in engineering education: The future is now," presented at the Proceedings of the Canadian Society for Civil Engineering Annual Conference 2023, Cham: Springer 2024.

[3] K. Zhang and A. B. Aslan, "AI technologies for education: Recent research & future directions," *Computers and Education: Artificial Intelligence,* vol. 2, p. 100025, 2021. https://doi.org/10.1016/j.caeai.2021.100025

[4] J. Abu Qadourah, A. a. M. Al-Falahat, and S. S. Alrwashdeh, "Investigate the carbon footprints of three intermediate flooring systems: Cross-laminated timber, solid concrete, and hollow-core precast concrete," *Journal of Applied Engineering Science,* vol. 20, no. 2, pp. 377-385, 2022. https://doi.org/10.5937/jaes0-32783

[5] S. S. Alrwashdeh, H. D. Ammari, Y. S. Jweihan, J. Abu Qadourah, M. J. Al-Kheetan, and A. a. M. Al-Falahat, "Refurbishment of existing building toward a surplus energy building in Jordan," *The Open Construction and Building Technology Journal,* vol. 16, no. 1, pp. 1-13, 2022. https://doi.org/10.2174/18748368-v16-e2208150

[6] S. S. Alrwashdeh, J. A. Qadourah, and A. a. M. Al-Falahat, "Investigation of the effect of roof color on the energy use of a selected house in Amman, Jordan," *Frontiers of Mechanical Engineering,* vol. 8, p. 897170, 2022. https://doi.org/10.3389/fmech.2022.897170

[7] P. Hadiyan and W. Zukhruf Nur, "AI chatbot distractions and academic triumphs: A mediation approach with self-control and coping skills," *Journal of Accounting and Investment*, vol. 25, no. 2, pp. 673-691doi: https://doi.org/10.18196/jai.v25i2.20755.

[8] S. Hobert, A. Følstad, and E. L.-C. Law, "Chatbots for active learning: A case of phishing email identification," *International Journal of Human - Computer Studies,* vol. 179, p. 103108, 2023. https://doi.org/10.1016/j.ijhcs.2023.103108

[9] E. International Conference on Artificial Intelligence in, A. M. Olney, I.-A. Chounta, Z. Liu, O. C. Santos, and I. I. Bittencourt, "Artificial intelligence in education: Posters and late breaking results, workshops and tutorials, industry and innovation tracks, practitioners, doctoral consortium and blue sky," in *25th International Conference, AIED 2024, Recife, Brazil, July 8-12, 2024, Proceedings. Part I, Cham, Springer*, 2024, in Communications in computer and information science; 2150, doi: 10.1007/978-3-031-64315-6. [Online]. Available: https://doi.org/10.1007/978-3-031-64315-6

[10] C.-C. Lin, A. Y. Q. Huang, and O. H. T. Lu, "Artificial intelligence in intelligent tutoring systems toward sustainable education: A systematic review," *Smart Learning Environments,* vol. 10, no. 1, p. 41, 2023. https://doi.org/10.1186/s40561-023-00260-y

[11] Y. Walter, "Embracing the future of Artificial Intelligence in the classroom: The relevance of AI literacy, prompt engineering, and critical thinking in modern education," *International Journal of Educational Technology in Higher Education,* vol. 21, no. 1, p. 15, 2024. https://doi.org/10.1186/s41239-024-00448-3

[12] J. Southworth *et al.*, "Developing a model for AI across the curriculum: Transforming the higher education landscape via innovation in AI literacy," *Computers and Education: Artificial Intelligence,* vol. 4, p. 100127, 2023. https://doi.org/10.1016/j.caeai.2023.100127

[13] A. a. M. Al-Falahat, "Examination of the dynamic behaviour of the composite hollow shafts subject to unbalance," *International Journal of Mechanical Engineering and Robotics Research,* vol. 10, no. 10, pp. 572-576, 2021.

[14] A. a. M. Al-Falahat, "Implementation of the dynamic balancing approach of a rotating composite hollow shaft," *EUREKA: Physics and Engineering,* no. 2, pp. 68-73, 2022. https://doi.org/10.21303/2461-4262.2022.002336

[15] A. a. M. Al-Falahat and S. S. Alrwashdeh, "Comprehensive engineering analysis of PEMFC gas diffusion layers: Simulation-based evaluation of four groundbreaking structural modifications," *Results in Engineering,* vol. 25, p. 104298, 2025. https://doi.org/10.1016/j.rineng.2025.104298

[16] S. Grassini, "Shaping the future of education: Exploring the potential and consequences of AI and ChatGPT in educational settings," *Education Sciences,* vol. 13, no. 7, p. 692, 2023. https://doi.org/10.3390/educsci13070692

[17] S. S. Alrwashdeh, Q. Al-Kaseasbeh, M. Al-Qaralleh, and A. a. M. Al-Falahat, "Recycling of materials industrial waste into a new composite alloy using sintering technique," *Results in Engineering,* vol. 26, p. 104975, 2025. https://doi.org/10.1016/j.rineng.2025.104975

[18] S. S. Alrwashdeh, M. R. Almajali, F. M. Alsaraireh, and A. a. M. Al-Falahat, "Green performance enhancement of marine engines via turbocharger compression ratio optimization," *Results in Engineering,* vol. 24, p. 102989, 2024. https://doi.org/10.1016/j.rineng.2024.102989

[19] S. Joksimovic, D. Ifenthaler, R. Marrone, M. De Laat, and G. Siemens, "Opportunities of artificial intelligence for supporting complex problem-solving: Findings from a scoping review," *Computers and Education: Artificial Intelligence,* vol. 4, p. 100138, 2023. https://doi.org/10.1016/j.caeai.2023.100138

[20] T. Ahmad *et al.*, "Artificial intelligence in sustainable energy industry: Status Quo, challenges and opportunities," *Journal of Cleaner Production,* vol. 289, p. 125834, 2021. https://doi.org/10.1016/j.jclepro.2021.125834

[21] S. W. Kim, J. H. Kong, S. W. Lee, and S. Lee, "Recent advances of artificial intelligence in manufacturing industrial sectors: A review," *International Journal of Precision Engineering and Manufacturing,* vol. 23, no. 1, pp. 111-129, 2021. https://doi.org/10.1007/s12541-021-00600-3

[22] J. Abu Qadourah, "Energy efficiency evaluation of green roofs as a passive strategy in the mediterranean climate," *Results in Engineering,* vol. 23, p. 102519, 2024. https://doi.org/10.1016/j.rineng.2024.102519

[23] A. a. M. Al-Falahat, Q. Abu, and S. S. Alrwashdeh, "Economic feasibility of heating source conversion of the swimming pools," *Journal of Applied Engineering Science,* vol. 20, no. 1, pp. 276-284, 2022. https://doi.org/10.5937/jaes0-34474

[24] X.-T. Feng *et al.*, "Artificial intelligence technology in rock mechanics and rock engineering," *Deep Resources Engineering,* vol. 1, no. 2, p. 100008, 2024. https://doi.org/10.1016/j.deepre.2024.100008

[25] J. A. Qadourah, "Evaluating solar-active shading solutions: A study of energy performance in Mediterranean residential architecture," *Architectural Engineering and Design Management,* vol. 20, no. 5, pp. 1222-1237, 2023. https://doi.org/10.1080/17452007.2023.2267570

[26] J. V. Vidal *et al.*, "Prediction of dynamic behaviors of vibrational-powered electromagnetic generators: Synergies between analytical and artificial intelligence modelling," *Applied Energy,* vol. 376, p. 124302, 2024. https://doi.org/10.1016/j.apenergy.2024.124302

[27] S. Amani *et al.*, "Generative AI perceptions: A survey to measure the perceptions of faculty, staff, and students on generative AI tools in academia," *arXiv preprint arXiv:2304.14415,* 2023. https://doi.org/10.48550/arXiv.2304.14415

[28] C. K. Y. Chan and W. Hu, "Students' voices on generative AI: Perceptions, benefits, and challenges in higher education," *International Journal of Educational Technology in Higher Education,* vol. 20, no. 1, p. 43, 2023/07/17 2023. https://doi.org/10.1186/s41239-023-00411-8

[29] S. Filippi and B. Motyl, "Development of a tool for evaluating the influence of engineering students' perception of generative AI on university courses based on personality, perceived roles in design teams, and course engagement," *Multimodal Technologies and Interaction,* vol. 8, no. 10, p. 84, 2024. https://doi.org/10.3390/mti8100084

[30] M. Yabaku and S. Ouhbi, "University students' perception and expectations of generative AI tools for software engineering," presented at the 024 36th International Conference on Software Engineering Education and Training (CSEE&T), 2024.

[31] A. Ali, R. Khan, and L. Zhang, *Artificial intelligence in engineering education: Impacts on problem-solving and creativity* London: Springer, 2024.

[32] O. Ali, P. Murray, M. M. Momin, Y. K. Dwivedi, and T. Malik, "The effects of artificial intelligence applications in educational settings: Challenges and strategies," *Technological Forecasting and Social Change,* vol. 199, p. 123076, 2024. https://doi.org/10.1016/j.techfore.2023.123076

[33] J. Jenis, J. Ondriga, S. Hrcek, F. Brumercik, M. Cuchor, and E. Sadovsky, "Engineering applications of artificial intelligence in mechanical design and optimization," *Machines,* vol. 11, no. 6, p. 577, 2023. https://doi.org/10.3390/machines11060577

[34] A. Johri, A. S. Katz, J. Qadir, and A. Hingle, "Generative artificial intelligence and engineering education," *Journal of Engineering Education,* vol. 112, no. 3, pp. 572-577, 2023. https://doi.org/10.1002/jee.20537

[35] S. Alnusairat and J. A. Qadourah, "Moving to green technologies: acceptance and perception of architectural solar photovoltaic technology for residential buildings," *Architectural Engineering and Design Management,* vol. 21, no. 2, pp. 338-355, 2024. https://doi.org/10.1080/17452007.2024.2361819

[36] J. A. Qadourah, "Improving natural ventilation in multi-story buildings within hot and dry climates: A CFD study of windcatcher performance," *Civil Engineering and Architecture,* vol. 12, no. 2, pp. 1014–1026, 2024. https://doi.org/10.13189/cea.2024.120225

[37] M. Soori, B. Arezoo, and R. Dastres, "Artificial intelligence, machine learning and deep learning in advanced robotics, a review," *Cognitive Robotics,* vol. 3, pp. 54-70, 2023. https://doi.org/10.1016/j.cogr.2023.04.001

[38] P. K. Ambadekar, S. Ambadekar, C. M. Choudhari, S. A. Patil, and S. H. Gawande, "Artificial intelligence and its relevance in mechanical engineering from Industry 4.0 perspective," *Australian Journal of Mechanical Engineering,* vol. 23, no. 1, pp. 110-130, 2025. https://doi.org/10.1080/14484846.2023.2249144

[39] W. Holmes, M. Bialik, and C. Fadel, *Artificial intelligence in education: Promises and implications for teaching and learning*. Boston, MA: Center for Curriculum Redesign., 2019.

[40] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, "Systematic review of research on artificial intelligence applications in higher education – where are the educators?," *International Journal of Educational Technology in Higher Education,* vol. 16, p. 39, 2019. https://doi.org/10.1186/s41239-019-0171-0

[41] M. J. Israel and A. Amer, "Ethical implications of digital infrastructures for pluralistic perspectives," *Ethics and Information Technology,* vol. 23, no. 3, pp. 399-417, 2021. https://doi.org/10.1007/s10676-021-09600-9

[42] S. Alnusairat, J. Abu Qadourah, and R. Khattab, "Assessing the future city post COVID-19: Linking the SDGs, health, resilience, and psychological impact," *Sustainability,* vol. 15, no. 1, p. 811, 2023. https://doi.org/10.3390/su15010811

[43] N. Selwyn, *Should robots replace teachers?: AI and the future of education*. Cambridge, UK: Polity Press, 2019.

[44] J. Abu Qadourah and S. Alnusairat, "Integrating aesthetics and sustainability: Evaluating the aesthetic perception of photovoltaic installation on the apartment building façade in Jordan," *Archnet-IJAR: International Journal of Architectural Research,* 2024. https://doi.org/10.1108/ARCH-02-2024-0038

[45] S. Alnusairat and J. A. Qadourah, "Sociological imagination on green technology: The influence of occupational and professional background on the architectural photovoltaic application," presented at the 2024 9th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE), 2024.

[46] A. Michel, *The impact of artificial intelligence on learning, teaching, and education policies for the future. In I. Tuomi (Ed.), Joint Research Centre, Publications Office of the European Union*. Luxembourg: Publications Office of the European Union, 2019.