

Responsible Data and AI Practices in Engineering Education: Preparing Graduates for Digital Transformation in Industrial Processes

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Abstract

INTRODUCTION: As artificial intelligence (AI) tools become increasingly integrated into higher education, understanding how engineering students perceive and apply principles of academic integrity, data integrity and responsible AI use has become increasingly important.

OBJECTIVES: This study investigates how master's engineering students perceive and apply principles of academic integrity, data integrity, and responsible AI use. It also explores the potential relevance of these practices for the development of competencies associated with participation in data-driven and AI-enabled professional environments.

METHODS: A mixed-methods approach was employed using the PEDRA questionnaire (Perceptions on Ethics and Development of Responsibility in Academia), developed by the authors. The instrument was designed to explore students' perceptions, experiences, and ethical reasoning regarding academic integrity and responsible research practices. The analysis focused on two questionnaire items addressing the influence of academic honesty on data use and the frequency of AI tool use in academic activities. The study involved master's engineering students from two higher education institutions.

RESULTS: Based on the 48 complete responses analysed, the findings indicate awareness of data integrity principles, particularly regarding anonymity, confidentiality, informed consent, and rigorous data analysis. Ethical referencing and transparency in data handling were mentioned less frequently, suggesting areas for further educational support. Regarding AI adoption, 21 of 48 respondents (43.8%) reported occasional use of AI tools, reflecting a cautious and exploratory approach. Descriptive differences in AI use were observed across age and gender groups, with female respondents being more likely to explore AI while maintaining ethical awareness, although these findings should be interpreted with caution.

CONCLUSION: The study highlights the importance of integrating responsible data and AI practices into engineering education. The results suggest that developing students' capacity to use data and AI critically, transparently, and ethically may support the development of competencies associated with responsible participation in increasingly digital and AI-enabled environments. The PEDRA questionnaire demonstrates potential as an exploratory and diagnostic instrument for identifying educational needs related to academic integrity, responsible AI use, data integrity, and trustworthy digital practice.

Keywords: Responsible AI Literacy, Digital Transformation, Industrial Engineering Education, Data Integrity, Digital Trust, Industry 5.0, Academic Integrity.

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1. Introduction

Digital transformation is reshaping industrial processes by integrating artificial intelligence, data analytics, cyber-physical systems, automation, digital twins, and interconnected decision-support environments. However, the success of these transformations depends not only on technological infrastructure but also on engineers' ability to work with data and artificial intelligence (AI) in a responsible, transparent, and ethically grounded manner. As industrial environments become more data-intensive, engineers are expected to make decisions supported by digital tools, algorithmic outputs, and complex datasets. In this context, data integrity, transparency, accountability, and responsible AI use are no longer marginal ethical concerns; they are core professional competencies. Errors, omissions, biased interpretations, inappropriate uses of AI-generated content, or a lack of transparency in data handling may compromise the reliability of technical decisions and the trustworthiness of digitally mediated industrial processes. Therefore, preparing engineering graduates for digital transformation requires technical knowledge, ethical awareness, and responsible decision-making.

1.1 Digital Transformation in Industrial Processes and Responsible Data Practices

Digital transformation is reshaping industrial processes by integrating AI, data analytics, cyber-physical systems, automation, digital twins, and interconnected decision-support environments. Industry 4.0 technologies have been identified as key drivers and enablers of digital transformation, influencing business practices, organizational processes, routines, and strategic decision-making [1]. In the specific context of industrial operations, Manufacturing Execution Systems are evolving from production-tracking tools into intelligent, AI-driven platforms integrated with IoT, cloud computing, and cyber-physical systems, enabling real-time decision-making and operational efficiency [2].

However, the success of digital transformation depends not only on technological infrastructure but also on engineers' capacity to work with data and AI in a responsible, transparent, and ethically grounded manner. As industrial organizations increasingly rely on data-driven decision-making, competencies in data integrity, AI literacy, accountability, transparency, and digital trust are essential for future engineering professionals. Errors in data interpretation, lack of transparency in data handling, inappropriate use of AI-generated outputs, or weak accountability may compromise the reliability of technical decisions and the trustworthiness of digitally mediated industrial processes.

This concern is reinforced by the transition from Industry 4.0 to Industry 5.0. While Industry 4.0 emphasizes digitalization, connectivity, automation, and data-driven industrial systems, Industry 5.0 complements this perspective by emphasizing research and innovation as drivers of a sustainable, human-centric, and resilient European industry [2, 3]. From this perspective, engineers are not only users of

digital technologies; they are also responsible agents who must understand the ethical, methodological, and social implications of data-driven and AI-supported decisions.

Therefore, preparing engineering graduates for digital transformation requires more than technical expertise. It also involves developing responsible data practices, critical AI literacy, and ethical awareness. These competencies may be relevant to trustworthy digital practice in future industrial contexts.

Although this study is situated within engineering education, the competencies examined, namely academic integrity, data integrity, transparency, and responsible AI use, are increasingly recognised as important foundations for responsible professional practice in data-driven and AI-enabled environments. Recent studies highlight that, alongside technical expertise, engineers operating in digitally transformed contexts require competencies related to ethical responsibility, critical thinking, accountability, and the responsible use of AI-enabled technologies [4, 5].

1.2 Academic and Ethical Integrity in Engineering Education

Academic and ethical integrity are foundational to credible scholarship and responsible professional practice [6]. In engineering education, such principles are relevant because students are prepared to act in contexts where technical decisions are increasingly supported by data, digital tools, and AI-based systems. Academic integrity involves values such as honesty, originality, transparency, responsibility and respect for intellectual property [7]. These values are also connected with the trustworthy use of data and evidence in future engineering practice [8, 9].

This is particularly important in dissertation work involving qualitative or quantitative data. Qualitative research in engineering may involve human participants, case studies, interviews, questionnaires, and contextual analysis, making confidentiality, informed consent, anonymity, and data integrity central ethical requirements [10]. Quantitative analysis also requires methodological rigor, avoidance of manipulation, and transparent reporting of analytical procedures and results [11].

1.3 Role of AI Tools in Research and Associated Ethics Issues

AI technologies can streamline data analysis, support academic writing, translation, coding, and literature organization. These tools may enhance productivity and learning when used critically and transparently. However, they also raise ethical concerns related to originality, authorship, source attribution, data privacy, overreliance on automated outputs, and the distinction between legitimate support and academic misconduct. For engineering students, these concerns are particularly important because the ability to use AI responsibly in academic work may influence how

they later interact with AI-supported tools in professional and industrial contexts.

Responsible AI use should therefore be understood as more than plagiarism prevention. Plagiarism, intentional or unintentional, can undermine the validity of academic work, affecting the credibility and scientific rigor of the research [12]. Therefore, reflecting on one's practices and perceptions of academic integrity ensures that the dissertation is an ethical and exemplary piece of work.

1.4 Overview of Academic Integrity in Higher Education

Ethics can be seen from different perspectives. Ethical practice involves attending to the present moment in academic and professional environments. Although both are important and relevant, this section reviews ethics in academic higher education, focusing on academic integrity.

Academic integrity refers to a commitment to the fundamental values of honesty, trust, fairness, respect, responsibility, and courage, which guide ethical behaviour in learning, teaching, and research activities [13]. These principles support responsible scholarship and provide a foundation for ethical decision-making in academic communities. Academic dishonesty, in contrast, may take various forms, including plagiarism, cheating, data falsification, inappropriate collaboration, and misuse of academic resources [14, 15]. Understanding these behaviours is particularly important in contexts where students increasingly engage with digital tools and AI-supported technologies. Together, these principles provide a useful conceptual basis for discussing data integrity and the responsible use of AI in engineering education.

Authors in [16] noted that, in some cases, educational institutions do not address student academic dishonesty for many reasons, including psychological discomfort, high workload, and the time needed to plan assignments designed to minimize cheating. Despite these issues, it is important to identify the factors that lead students to cheat, as they may negatively interfere with the learning environment and the student learning process.

In the context of engineering education, academic integrity should be addressed not only through rules and sanctions, but also through explicit educational strategies that help students understand why integrity matters in data collection, analysis, reporting, and AI-supported work. This is especially relevant at the master's level, where dissertation work requires students to demonstrate autonomy, methodological rigor, originality, and ethical responsibility.

1.5 Study Objective and Contribution

This study explores how master's engineering students perceive and apply responsible data and AI practice in academic integrity and research-related activities, with particular attention to dissertation work and the use of AI tools. By focusing on students who are close to entering

professional contexts, the study connects academic integrity, data integrity, and responsible AI literacy with the preparation of engineering graduates for digitally transformed industrial environments.

The paper contributes to the literature in three main ways. First, it reframes academic integrity as part of a broader set of responsible data and AI competencies required for digital transformation. Second, it presents the PEDRA (Perceptions on Ethics and Development of Responsibility in Academia) questionnaire as a structured instrument for exploring students' perceptions and practices concerning academic integrity, data handling, dissertation research, and AI-supported academic work. Third, it identifies educational implications for engineering curricula, dissertation supervision, and institutional guidelines to strengthen responsible AI literacy, data integrity, and trustworthy digital practice. PEDRA questionnaire was previously applied in a study exploring engineering students' perceptions of ethical challenges in academic research contexts, where its structure and application were first presented [17].

Building on that work, the present study focuses on selected PEDRA dimensions related to responsible AI use and data integrity. Rather than addressing instrument development, the study analyses how engineering master's students perceive these issues and discuss their potential relevance for the development of responsible professional practices in increasingly digitalised environments.

The remainder of this paper is structured as follows: Section 2 outlines the research methodology, including the research questions, the PEDRA questionnaire design, the validation process, the data collection strategies, and the analytical approaches. Section 3 interprets and discusses the main findings regarding students' use of AI tools and responsible data practices. Section 4 summarizes key findings, their implications for engineering education and digital transformation, and identifies directions for future research.

2. Research Methodology

This section describes the methodological approach adopted to investigate master's engineering students' perceptions and practices regarding academic integrity, data integrity, and responsible AI use in academic and dissertation-related activities.

2.1 Research Design, Research Questions, and Data Analysis

This study adopts a mixed-methods approach, combining quantitative and qualitative data, to explore how master's engineering students perceive and apply responsible data and AI practices in academic and research-related contexts. The combination of closed-ended and open-ended questions enabled the integration of descriptive statistical analysis with qualitative thematic interpretation, allowing both general response patterns and students' ethical reasoning to be

examined. The study was guided by the following research questions:

- RQ1: How do master's engineering students report the use of AI tools in academic and research-related tasks?
- RQ2: How do master's engineering students perceive and apply principles of academic integrity, data integrity, and transparency in dissertation-related work?
- RQ3: What educational gaps can be identified regarding responsible data and AI practices that are relevant to preparing engineering graduates for digitally transformed industrial contexts?

Closed-ended questions were analysed using descriptive statistics, mainly frequencies and percentages, to identify patterns in students' reported AI tools use and perceptions of academic integrity. Open-ended responses were analysed through thematic interpretation, focusing on students' perceptions, experiences, and reasoning regarding integrity, transparency, accountability, data handling, and ethical responsibility.

The study's core methodology is the PEDRA questionnaire (Perceptions on Ethics and Development of Responsibility in Academia), developed through a thorough review of relevant scientific literature on academic integrity, ethical challenges in qualitative research, and the role of AI in higher education. In this paper, PEDRA is positioned as a diagnostic instrument for identifying responsible data and AI practices in engineering education, with implications for preparing graduates for a profession shaped by digital transformation. A detailed description of the instrument development process and its initial application has been reported in previous work [17].

The following subsections describe the PEDRA questionnaire structure, validation process, data collection procedures, and data analysis procedures.

2.2 PEDRA Questionnaire: Conceptual Framework and Design Approach

PEDRA is a research instrument designed to explore master's students' perceptions, knowledge, and practices concerning academic integrity, responsible data handling, and AI-supported academic work.

Although the questionnaire was originally developed in the academic integrity context, its structure also allows it to identify dimensions relevant to responsible digital practice, including transparency, accountability, data integrity, responsible use of AI tools, and ethical decision-making in research-related activities.

The name PEDRA was intentionally chosen to reflect the foundational role of academic integrity in higher education. In Portuguese, "*pedra*" means "stone," symbolizing a strong and enduring foundation. This metaphor extends to responsible digital transformation: just as a stone provides

stability to a structure, integrity supports the credibility of academic work, the trustworthiness of data practices, and the responsible use of AI-supported tools.

The PEDRA questionnaire comprises 28 questions organised into several thematic sections addressing plagiarism, ethical awareness and academic writing practices, including institutional policies, ethical decision-making, academic behaviours, and the influence of AI tools and internationalization on academic integrity.

The instrument included a mix of multiple-choice, Likert-scale, dichotomous, matrix, ranking, and open-ended questions. This structure enabled both quantitative description of response patterns and qualitative analysis of students' experiences and reasoning.

PEDRA was designed to be completed in approximately 5–8 minutes, aiming to encourage participation while maintaining sufficient coverage of the main dimensions under study.

Table 1 provides an overview of the complete instrument, presenting each section, the corresponding question groups, their identification codes, objectives, and question types. This structure helps readers understand the questionnaire's scope and organization and contextualize the questions analysed in this study within the broader framework of responsibilities and ethical practices assessed by PEDRA. PEDRA was designed as an exploratory and diagnostic instrument intended to investigate students' perceptions, experiences, and ethical reasoning regarding academic integrity and responsible research practices. The questionnaire was not developed as a scoring or certification tool and therefore does not generate an overall score or classification index. Instead, individual questions and thematic groups are analysed according to the objectives of each study. A detailed description of the instrument and its initial application is available in [17]. The first section, Student Profile and Academic Background, gathers demographic and academic information, including gender, age, program enrolment, dissertation stage, prior educational context, and prior self-reported behaviours related to academic dishonesty and AI tool use (Q1-Q9). These variables contextualize students' responses and support the identification of patterns linked to digital tool adoption.

The second section, Knowledge, Perceptions, and Experiences with Academic Integrity (Q10-Q15), assesses students' awareness of institutional ethics policies, their exposure to discussions on plagiarism, citation, AI-assisted writing, and their perceptions of academic misconduct. This section helps identify how institutional guidance may support or limit the development of responsible academic and digital practices. The questions' design was guided by studies highlighting the importance of structured institutional guidance in fostering academic integrity among students in the information age [18] and the role of accountability through integrity in balanced education [19]. The third section, Academic Misconduct and Ethical Decision-Making, examines students' ethical decision-making by presenting real-world scenarios (Q16). These scenarios include behaviours such as copying, inappropriate collaboration, use of AI without citation, and other forms of misconduct. This

section helps identify possible misunderstandings about the boundaries between acceptable support, unethical behaviour, and plagiarism. The design of this section was informed by research showing that targeted education on academic misconduct can reduce plagiarism and improve students'

understanding of ethical behaviour [20], as well as by studies highlighting varied perceptions of plagiarism among STEM graduate students [21].

Table 1. Perceptions on Ethics and Development of Responsibility in Academia (PEDRA) main structure

Section	Group of Questions Code	Group of Questions Identification	Group Questions Objective	Group Questions Type
1	Q1 – Q5	Gender, Age, and Program Enrolment	Helps categorize respondents based on key demographic variables.	Multiple-choice questions
	Q6	Dissertation Progress	Determines the student's stage in the dissertation process, influencing their exposure to academic integrity issues.	Multiple-choice questions
	Q7	Previous Education Context	Identifies whether the student completed their undergraduate studies in Portugal or abroad, allowing for comparisons across different educational experiences.	Dichotomous (Yes/No)
	Q8-Q9	Prior Academic Dishonesty	Explores self-reported experiences with misconduct, including copying in exams and the use of AI tools for academic tasks, providing insights into behavioural trends.	5-point Likert scale of frequency
2	Q10-Q10b	Awareness of Institutional Ethics Policies	Measures whether students are informed about their university's academic integrity policies and where they learned about them.	Dichotomous / multiple-choice questions / 4-point Likert scale
	Q11	Discussions of Ethical Topics in Academic Settings	Evaluates how frequently professors discuss topics related to plagiarism, proper citation, and AI-assisted writing, revealing gaps in ethical education.	Matrix questions with 5-point Likert scale of frequency
	Q12	Severity of Different Types of Plagiarism	Asks students to classify different types of academic misconduct, from collaboration in individual assignments to direct plagiarism, providing insights into their moral reasoning.	Ranking questions
	Q13	Attitudes Toward Plagiarism and Institutional Policies	Uses a Likert scale to measure students' opinions on how seriously plagiarism is treated within their institution.	5-point Likert scale of agreement
	Q14-Q15	Personal Experiences and Additional Comments	Open-ended questions allow students to share experiences and suggestions, giving qualitative insights into their perceptions.	Open-ended questions

Section	Group of Questions Code	Group of Questions Identification	Group Questions Objective	Group Questions Type
3	Q16	Behavioural Assessment	Asks students to categorize different behaviours (e.g., copying homework, using AI without citation or taking exams for others) as plagiarism, unethical but not plagiarism, or acceptable.	Ranking questions
	Q17	Use of Citation Management Tools	Identifies whether students use software for proper citation management.	Dichotomous (Yes/No)
	Q18-Q19	Discussion of Originality in Research	Explores whether students receive formal guidance on ensuring originality in their dissertations.	Dichotomous (Yes/No) / Open-ended question
4	Q20-Q21	Use of Mixed Research Methods and Data Integrity	Investigates how students ensure qualitative and quantitative data integrity in dissertation-related work.	Open-ended questions
	Q22	Training in Ethical Source Usage	Assesses whether students have received training on proper citation and its impact on their work.	Open-ended question
	Q23-Q24	Academic Writing Skills and Ethical Research Practices	Encourage students to reflect on their writing skills and whether they feel adequately prepared for ethical academic work.	Open-ended questions
5	Q25	Perceived Impact of AI on Academic Writing and Skills Development	Evaluates whether students believe AI-generated content hinders academic writing skills.	Open-ended question
	Q26-Q26a	Experience with International Mobility Programs	Explores how studying abroad influences students' understanding of academic ethics.	Dichotomous (Yes/No) / Open-ended question
	Q27	Cultural Differences in Academic Integrity Expectations	Investigates whether students perceive variations in ethical standards across different countries.	Open-ended question
	Q28	Institutional Support for Ethical Internationalization	Collects feedback on whether universities adequately support international students in understanding academic integrity expectations.	Open-ended question

The fourth section, Ethical Practices in Dissertation Writing and Research Methods, focuses on how students apply principles of academic integrity in dissertation-related work (Q17-Q24). It addresses source management, originality, citation practices, handling of qualitative and quantitative data, and perceived preparation for ethical academic writing. This section is particularly relevant to

the present study because dissertation work requires students to engage with data collection, analysis, interpretation, and reporting. It was designed with the importance of academic integrity in fostering credible and impactful research in higher education in mind [22]. This section is displayed only to students who have already started the dissertation, namely those in the initial or final

phase, with phases of writing, awaiting defence scheduling, or those who have defended their dissertation within the previous year.

The fifth section, Perspectives on Academic Ethics, AI Tools and Internationalization, explores students' perceptions of AI tools, academic writing, international academic experiences, and institutional support for ethical practice (Q25-Q28). This section is relevant to understanding how AI-supported academic work and culturally diverse academic contexts may influence students' perceptions of integrity, transparency, and responsible use of digital tools. It was informed by literature discussing the challenges posed by AI tools such as ChatGPT in maintaining academic integrity [23, 24], as well as broader ethical dilemmas associated with AI and international academic collaborations [25].

For this study, the analysis focuses on two items that directly address the research objectives: Q9, which concerns the use of AI tools for academic work, and Q21, which concerns students' perceptions of data integrity and ethical responsibilities in research. These items were selected because of their direct relevance to responsible digital practices and the competencies required in data-driven environments.

2.3 Coding and Validation Process

The validity of the PEDRA questionnaire was assessed through a comprehensive review focusing on grammatical accuracy, syntactic clarity, and conceptual coherence, and relevance to the constructs under study. Attention was given to ensuring that the questionnaire items were understandable and capable of capturing students' perceptions and practices regarding academic integrity, data handling, dissertation research, and AI-supported academic work.

The wording and structure of the items were refined to avoid ambiguity and improve consistency across the questionnaire. This process was aligned with several recommendations on linguistic precision, face validity, and content validity in engineering education research [26].

Attention was given to the semantic equivalence of translated terms, ensuring that key concepts related to plagiarism, ethical decision-making, and AI-assisted research were accurately conveyed. This step aligns with the semantic validation approach, in which terminology maintains consistent meaning across cultural contexts.

A pilot test with master's engineering students identified potential misunderstandings, leading to targeted adjustments in phrasing and structure to enhance readability and interpretability. Expert reviews from academic integrity specialists and engineering education researchers provided critical insights into construct validity. The validation process recommendations from assessment research in engineering education, particularly regarding the importance of linguistic precision and conceptual clarity in questionnaire design [27].

2.4 Data Collection Strategy and Participants

In December 2024, PEDRA was made available through the *LimeSurvey* online platform and distributed through master's program committees, inviting students to participate. An introductory text explained the purpose of the PEDRA questionnaire, highlighting the importance of participation in better understanding students' challenges in developing original, high-quality academic work and in promoting ethical practices in research and academic writing.

The study used a voluntary, anonymous questionnaire to assess students' perceptions of academic integrity, data integrity, and AI use, and used responses exclusively for academic research purposes. No personally identifiable information was collected. Participants were informed of the study objectives, the voluntary nature of participation, and the confidential treatment of responses. Completion of the questionnaire was considered to indicate informed consent. Students were also encouraged to share the questionnaire link within their academic networks to maximize participation and enrich the dataset. A total of 57 students accessed the questionnaire. After excluding incomplete responses, 48 fully completed questionnaires were retained for analysis, corresponding to an 84.2% completion rate. This set of complete responses provided a consistent dataset for identifying key patterns and insights relevant to the study's research questions.

The sample consisted of master's students from two higher education institutions, one public and one private. Most participants were female (54%). Regarding age distribution, 42% of participants were 25 years or older, 33% were 23-24 years old, and 25% were 21-22 years old. In terms of academic background, 57% of participants were enrolled in Industrial Engineering and Management. The remaining students were distributed across Engineering and Operations Management, Industrial Electronics and Computer Engineering, Textile Engineering, Aerospace Engineering, and Mechanical Engineering. This diversity is relevant because responsible data and AI practices are increasingly important across multiple engineering domains.

Regarding academic progression, only one student was in the first year of a master's program, while the majority were in the second year. Among them, 21% were preparing their dissertation, 30% were in the initial stage, and 40% had completed their defenses within the previous year. The remaining students were either finalizing their dissertations or waiting for the defense to be scheduled. Additionally, two students completed their bachelor's degrees abroad, one in England and one in Brazil.

3. Results and Discussion

This section presents and discusses the main findings obtained from selected questions of the PEDRA questionnaire. The analysis aligns with the three research

questions and focuses on students' reported use of AI tools, their application of academic and data integrity principles in dissertation-related work, and the educational gaps that may affect their preparation for responsible participation in digitally transformed industrial contexts.

For this paper, two PEDRA questions were selected as central empirical sources:

- Q9: During your years as a student, have you used AI tools (like ChatGPT or others) to generate parts of assignments or exercises? Response scale: [Never / Rarely / Occasionally / Frequently / Always]
- Q21: How did academic honesty principles influence your use of qualitative (e.g., interviews, questionnaires) and quantitative (e.g., statistical analyses) data in your dissertation?

Q9 supports the analysis of students' reported use of AI-assisted research and writing, offering a current and practical perspective on how AI tools affect students' ethical behaviour in academia, directly addressing RQ1. Q21 provides qualitative insights into how students perceive and apply academic integrity, data integrity, and transparency in dissertation-related work, addressing RQ2. Together, these questions also support the identification of educational gaps related to responsible data and AI practices, contributing to RQ3. Demographic variables, namely age and gender, were also considered to contextualize AI tool usage patterns.

3.1 Students' Reported Use of AI Tools

Among the 48 complete respondents, 21 (43.8%) reported occasional AI use, 11 (22.9%) rare use, 8 (16.7%) frequent

use, and the remaining respondents reported no use; none reported always using AI. These self-reported frequencies describe use, not its purpose, appropriateness, or ethical quality.

This distribution suggests that AI tools have become part of students' academic routines, but not yet in a fully consolidated or systematic way. The predominance of occasional use may indicate a cautious adoption, in which students explore AI tools for specific academic tasks without relying on them consistently. From the perspective of responsible AI literacy, this result is relevant because it shows that students are already interacting with AI-supported environments and require explicit guidance on the appropriate, transparent, and ethical use of AI.

The presence of a frequent-use group of AI (16.7%) also deserves attention. These students may be developing stronger familiarity with AI tools, but they may also be more exposed to risks associated with overreliance, unclear authorship, lack of disclosure, or inadequate verification of AI-generated outputs [23]. Conversely, the group that reported never using AI tools may include students who avoid AI due to ethical concerns, lack of confidence, lack of access, or insufficient guidance on acceptable use [20].

Figure 1 presents the distribution of AI tool usage across age groups of master's students. The results suggest that younger students were more likely to have engaged with AI tools, since no students aged 21–22 years reported never using them. Students aged 23–24 years showed a stronger concentration in occasional use (56.2%), while older students (25+ years) showed a more dispersed distribution, with higher proportions of non-use (30%) and occasional use (40%). The age-related distribution supports insights from [20] on the role of academic experience in shaping students' engagement with AI-generated content.

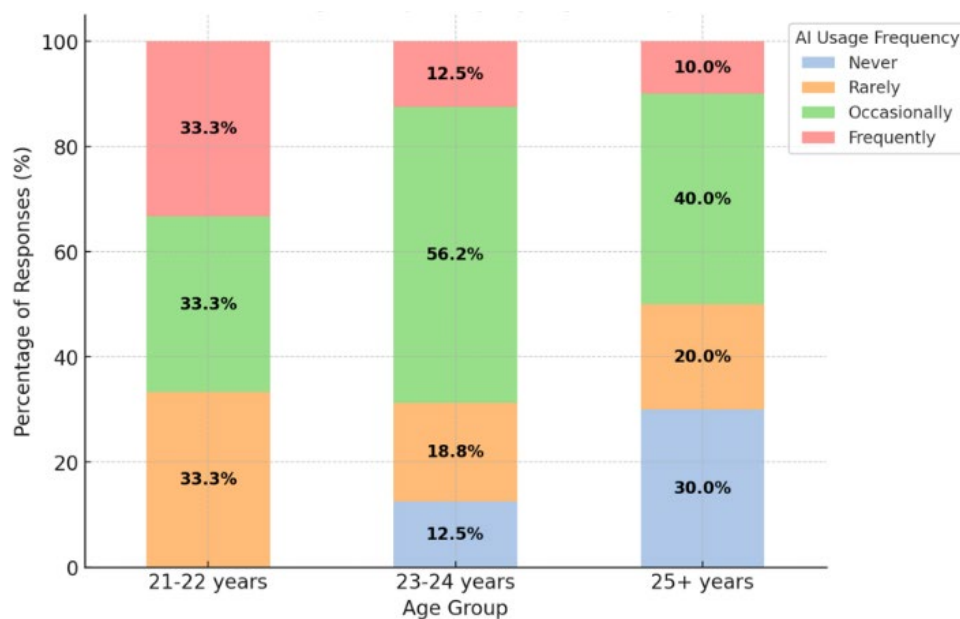


Figure 1. Distribution of AI tool usage across master's students' age groups

Figure 2 presents the distribution of AI tool usage by gender. Gender-related patterns also suggest differentiated forms of AI adoption. Female students reported occasional AI use more frequently (53.8%) than male students (31.8%), suggesting a moderate and exploratory pattern of

engagement. However, given the sample size, these differences should be interpreted with caution and not used to infer broader gender-based differences in AI adoption, but rather as descriptive tendencies within this sample.

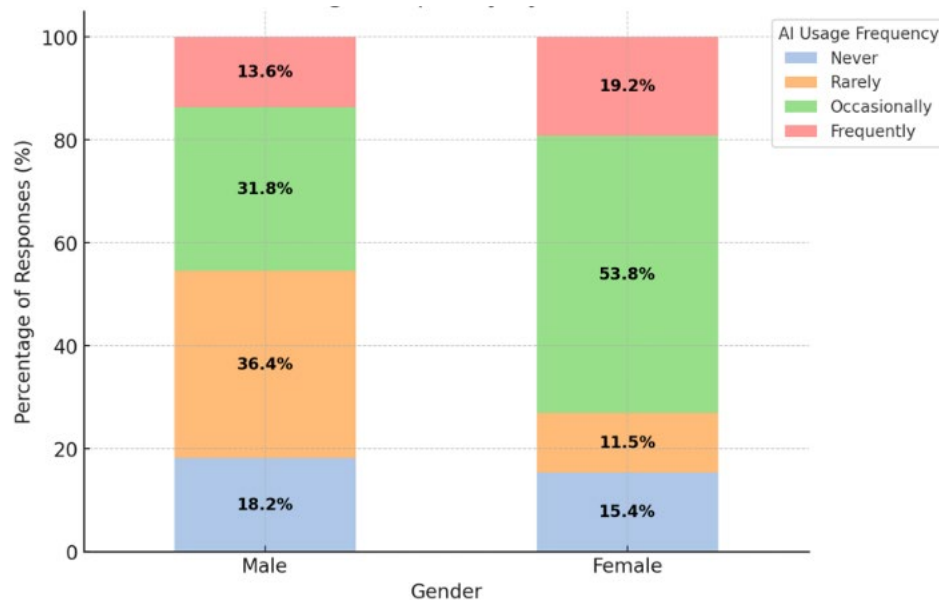


Figure 2. Distribution of AI tool usage across master's students' gender

Among female respondents, 19.2% (5 of 26) reported frequent use of AI tools. Given the small size of this subgroup, the finding should be interpreted with caution. Frequency of use reflects reported engagement with AI technologies but does not, by itself, demonstrate competence, reliance, or ethical awareness.

Overall, the RQ1 findings indicate that AI tools are already part of master's engineering students' academic practices, especially through occasional use. This reinforces the need for engineering programs to address AI use explicitly, not only as a matter of preventing academic misconduct, but also as part of responsible AI literacy and preparation for data-driven professional environments.

3.2 Responsible Data Practices in Dissertation-Related Work

The analysis of Q21 focused on how students described the influence of academic honesty principles on their use of qualitative and quantitative data in dissertation-related work. Responses were analysed through an inductive thematic analysis following the approach proposed by Braun and Clarke [28]. Following repeated readings of the responses, recurring concepts related to ethical research practices were identified, coded, and grouped into broader thematic categories through an iterative review process.

The analysis sought to explore how students perceived and applied principles of academic integrity and transparency in research activities, thereby addressing RQ2.

Of the 48 complete respondents, 15 (31.3%) indicated that they had not used qualitative or quantitative data in their dissertation or that the question was not applicable to their current stage of work. The remaining 33 (68.8%) provided comments to Q21. This result aligns with the participants' academic progression, as approximately 51% of the students were still preparing or beginning their dissertations.

The level of detail in the responses varied considerably. Many comments consisted of brief statements such as "NU" (not used), "Yes", or indications that dissertation work had not begun, providing limited information for qualitative interpretation. Consequently, the thematic analysis focused on responses containing explicit reflections on research practices and ethical considerations associated with data collection, analysis, and reporting.

Three themes emerged from the coded responses: Data Integrity, Transparency in Data Handling, and Ethical Referencing. Data Integrity emerged as the dominant theme, with students emphasizing the importance of accurately reporting results, maintaining original values, avoiding data manipulation, and ensuring the credibility of research findings. Transparency in Data Handling was

reflected in references to anonymity, confidentiality, informed consent, and the responsible management of research data. Ethical Referencing appeared less frequently and highlighted the importance of appropriately acknowledging sources to support the integrity and credibility of academic work. Overall, the findings suggest that students primarily associate academic honesty with the integrity and trustworthy management of research data rather than with citation practices alone.

Data integrity refers to data accuracy, consistency, and reliability throughout the research process. In qualitative research, maintaining data integrity involves ensuring ethical data collection, appropriate storage, and truthful reporting of findings. This theme was selected because qualitative research in engineering often involves human participants, making data protection and authentic representation of results crucial [7].

Authors in [22] also highlight that in engineering education, research validity depends heavily on data integrity. Ethical concerns, such as manipulating results or misrepresenting findings, directly compromise the credibility of academic work.

Ethical referencing ensures proper credit is given to sources, reflecting academic honesty and respect for intellectual property. In qualitative research, where the interpretation of existing theories and literature is fundamental, accurate referencing is essential to avoid plagiarism and maintain academic standards.

The importance of ethical referencing is further highlighted by [20], who demonstrate that academic misconduct education, primarily focused on plagiarism prevention, significantly reduces unethical behaviour. Ethical referencing takes on new dimensions with the increasing use of AI-generated content, as noted by the study [24].

This theme offers valuable insights into students' awareness and application of referencing standards, especially when addressing the challenges introduced by AI tools in academic work.

Transparency in data handling involves clear documentation of how data is collected, processed, and analysed. This theme was chosen because transparent research practices enable replicability and verification of findings, which are essential for the credibility of engineering research [19]. Transparency also relates to researchers' ethical responsibility to disclose potential biases and methodological limitations.

As authors in [23] highlighted, the rise of AI tools in academic settings necessitates greater transparency in their use, especially in qualitative research.

Data integrity was the most visible theme in students' responses (75.0%), reflecting concerns with accuracy, methodological rigor, and the avoidance of data manipulation. Transparency in Data Handling emerged in four responses (50.0%), particularly through references to anonymity, confidentiality, informed consent, and faithful reporting of results. Ethical referencing was mentioned less frequently (12.5%), although one respondent explicitly highlighted the importance of properly citing sources to

ensure research credibility. Percentages exceed 100% because a single response may contain more than one theme.

Students referred to practices such as preserving anonymity, ensuring confidentiality, avoiding result manipulation, and conducting analysis with methodological rigor. These elements suggest that students associate academic honesty with protecting participants, treating data correctly, and ensuring the credibility of research results. For example, two responses illustrate this concern clearly:

"I needed to handle the data anonymously and made sure to delete it after use."

"...I remained faithful to the results even when they were not the expected ones."

Another student provided a more complete account of data-related ethical practice:

"The principles of academic honesty guided the entire data collection and analysis process in my dissertation. For the questionnaires, I ensured informed consent and participant confidentiality. Regarding statistical analyses, I conducted them with methodological rigor and without manipulating results. All sources were properly cited, ensuring the integrity and credibility of the work."

These responses suggest that when students engage with dissertation data, they can identify important dimensions of responsible research conduct, especially anonymity, confidentiality, informed consent, and non-manipulation of results. These dimensions are consistent with the relevance of ethical development in engineering education [7] and with the need to treat ethical integrity in qualitative research as part of the methodological process, rather than only as procedural compliance [10]. This is also relevant to engineering education because responsible data practices are closely connected with the credibility and validity of research processes, particularly when students are expected to collect, analyse, interpret, and report data with rigor [15, 26], as mentioned by two students: *"... maintain the real values..."*, and *"... remained faithful to the results"*.

However, ethical referencing and transparency in data handling were less explicitly developed in students' responses. Although some students mentioned proper citation (*"...all sources were properly cited, ensuring the integrity and credibility of the work."*), most responses focused more strongly on confidentiality and non-manipulation than on documentation, traceability, disclosure of procedures, or transparency regarding analytical decisions. This suggests that students may understand data integrity primarily as the ethical protection of participants and the truthful treatment of data, while broader dimensions of transparency and reproducibility are less visible. This finding aligns with previous work emphasizing integrity and accountability as core dimensions of higher education [19], as well as with the importance of academic misconduct education, which strengthens students' understanding of plagiarism and ethical referencing [15, 20].

In relation to RQ2, the findings indicate that students are aware of key academic and data integrity principles,

particularly when handling dissertation data. However, their responses also suggest the need to strengthen explicit training on transparency, traceability, ethical referencing, and disclosure of data and AI-supported procedures. This need becomes particularly relevant in the context of AI-supported academic work, where questions of authorship, attribution, transparency, and the appropriate use of AI-generated content have become central to debates on academic integrity [23, 24].

3.3 Educational Gaps for Responsible Data and AI Practices

The combined analysis of Q9 and Q21 allows the identification of educational gaps related to responsible data and AI practices, addressing RQ3. These gaps are particularly relevant because master's engineering students are entering professional contexts where data-driven decision-making and AI-supported tools are increasingly embedded in industrial processes, including Industry 4.0-enabled organizational routines [1] and AI-supported Manufacturing Execution Systems [2]. Thus, gaps in students' responsible use of data and AI may affect not only academic work, but also their future capacity to contribute to trustworthy digital transformation in industry.

The first gap concerns responsible AI literacy. The results show that most students have already used AI tools at least occasionally. However, the data do not show whether students consistently know how to disclose AI use, verify AI-generated outputs, protect sensitive information, or distinguish acceptable support from inappropriate dependence. This gap is consistent with recent literature highlighting that the use of generative AI tools in academic contexts requires explicit guidance on authorship, attribution, transparency, and appropriate use, rather than relying only on traditional plagiarism approaches [23–25].

The second gap concerns transparency in data handling. Students' responses show awareness of confidentiality, anonymity, and non-manipulation, but less emphasis on documentation, reproducibility, traceability, and disclosure of analytical procedures. In academic work, this may affect the credibility of dissertation research. In professional engineering contexts, the same gap may affect the trustworthiness of data-driven decisions. This finding is relevant because integrity and accountability are central to credible academic work [19] while validity in engineering education research depends on the meaningful and rigorous treatment of data, methods, and interpretation [26]. In qualitative research, ethical integrity should also be embedded in the methodological process rather than treated only as procedural compliance [10].

The third gap concerns the connection between academic integrity and professional digital responsibility. Students may perceive academic integrity primarily as a set of institutional rules governing plagiarism, citation, and assessment. However, in the context of digital transformation, academic integrity can also be understood as preparation for responsible professional behaviour in

data-intensive and AI-supported environments. This interpretation is consistent with the broader transformation of industrial processes associated with Industry 4.0, where digital technologies reshape organizational processes, routines, and decision-making [1]. It also aligns with the Industry 5.0 perspective, which emphasizes human-centric, sustainable, and resilient technological innovation [3].

The fourth gap concerns institutional guidance and supervision. The diversity of AI use patterns suggests that students may be making individual decisions about AI-supported work without a shared framework. Some students use AI frequently, some occasionally, and others never. This diversity is not necessarily problematic, but it reinforces the need for clear institutional guidelines, supervision practices, and curricular discussions that help students understand how to use AI responsibly and transparently. Previous studies emphasize that academic integrity depends not only on students' individual decisions, but also on institutional cultures, structured guidance, and targeted educational interventions [10, 11, 13, 15].

Taken together, these findings suggest that responsible data and AI practices should be intentionally integrated into engineering education. Preparing graduates for digital transformation in industrial processes requires not only technical proficiency but also the ability to use data and AI critically, ethically, and transparently. Recent literature further emphasises that effective engagement with AI-enabled technologies requires competencies related to ethical awareness, accountability, critical evaluation, and responsible decision-making, alongside technical expertise. Such competencies are increasingly recognised as important for engineers expected to operate in data-driven and AI-enabled professional environments. This is consistent with a human-centric view of industrial transformation, in which technological innovation must be accompanied by responsibility, trustworthiness, and attention to people, organizations and society [3, 4].

This exploratory, cross-sectional study draws on 48 complete questionnaires responses collected from a convenience sample recruited through programme committees and student networks at two higher education institutions. The limited sample size and uneven subgroup sizes prevent population-level generalisation and causal inference. AI use was self-reported and may be affected by recall and social-desirability bias. Only two items from the 28-question PEDRA instrument were analysed; Q9 measures reported frequency rather than ethical competence, while the qualitative analysis of Q21 was based on a limited number of responses containing sufficient narrative detail for thematic interpretation. The industrial relevance discussed should therefore be interpreted cautiously, as it is conceptual and was not tested in professional settings. Nevertheless, the competencies explored in this study, including academic integrity, data integrity, transparency, and responsible AI use, have been identified in recent literature as increasingly relevant for engineers operating in data-driven and AI-enabled environments, where ethical responsibility, accountability,

and critical decision-making complement technical expertise [4, 5]. The qualitative coding process and the instrument's psychometric properties require fuller documentation and assessment.

4. Conclusions and Future Work

4.1 Study Limitations

This study analysed responsible data and AI practices among master's engineering students to explore how these practices may contribute to the development of competencies associated with responsible participation in digitally transformed environments. The analysis focused on students' reported use of AI tools and on the influence of academic honesty principles on the handling of qualitative and quantitative data in dissertation-related work.

Several limitations should be considered when interpreting the findings. The analysis drew on 48 complete responses from master's students at two higher education institutions, limiting the generalisability of the results. In addition, the convenience sampling approach and reliance on self-reported perceptions may introduce response and social desirability biases. The cross-sectional design captures perceptions at a single point in time and does not allow changes in attitudes or behaviours to be examined. Furthermore, although the PEDRA questionnaire comprises 28 questions, the present study focused on two items directly related to responsible AI use and data integrity. The qualitative analysis was also based on a limited number of responses containing sufficient narrative detail for thematic interpretation. Finally, the relationship between the identified competencies and professional engineering practice was not examined directly and therefore should be interpreted cautiously. Future studies involving larger and more diverse samples, longitudinal designs, and additional PEDRA dimensions would contribute to a broader understanding of these issues.

4.2 Conclusions and Future Work

The findings indicate that students already use AI tools in their academic practices, mainly on an occasional basis. This suggests an emerging but still cautious integration of AI into academic work. The findings also indicate that students who had engaged with dissertation-related data demonstrated awareness of several key principles of responsible research conduct, particularly anonymity, confidentiality, informed consent, methodological rigor, and the avoidance of data manipulation.

At the same time, the study identified several areas requiring further attention. Ethical referencing, transparency in data handling, traceability, and the explicit documentation of analytical procedures appeared less frequently in students' responses. These findings suggest that students tend to associate integrity principally with

participant protection and honest reporting of results, while broader dimensions of responsible research and data stewardship may be less developed.

The results highlight the need for clearer guidance in engineering education on responsible AI use, data integrity, transparency, and ethical research practices. This is particularly relevant at the master's level, where dissertation work represents an important stage in the development of professional and research-related competencies. Recent literature emphasises that effective engagement with AI-enabled technologies requires not only technical proficiency but also technical awareness, accountability, critical evaluation, and responsible decision-making. These competencies are increasingly recognised as important for engineers operating in data-driven and AI-enabled professional environments [4].

The PEDRA questionnaire offers a structured starting point for exploring students' perceptions and self-reported practices concerning academic integrity, data handling, dissertation research, and AI-supported academic work. As an exploratory and diagnostic instrument, its purpose is to support the investigation of ethical reasoning and responsible research rather than providing a scoring or certification framework. Additional studies are required to further examine its diagnostic utility, reliability, and validity across different educational contexts [17].

Future research should expand the analysis of open-ended responses and explore additional PEDRA dimensions, including institutional guidance, perceptions of plagiarism, citation practices, academic writing skills, and the perceived impact of AI on learning. Further studies involving larger and more diverse samples would help explore differences across engineering programs, dissertation stages, and student profiles, while also examining how competencies related to integrity, transparency, and responsible AI use evolve over time.

Overall, the findings suggest that preparing engineering graduates for increasingly digital and AI-enabled contexts requires more than technical proficiency alone. It also requires developing integrity, transparency, accountability, critical judgment, and responsible use of data and AI throughout academic and professional practice. Furthermore, the results highlight engineering education's potential to foster these competencies, which are increasingly recognized as important for responsible participation in data-driven and technologically mediated environments. In addition, future master's degree students with a previous professional experience should be included in the study.

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