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Integrating Generative AI in Engineering Education: A Longitudinal Framework on Personality, Roles, and Perceptions

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ABSTRACT

This study investigates how engineering students' personality traits, perceived team roles, and AI literacy influence their perceptions of generative Artificial Intelligence (Gen-AI) tools in university education. Building on previous frameworks that link psychological and behavioral variables to technology adoption, a longitudinal design was adopted across two academic years (2023–24 and 2024–25) at the University of Udine. The same validated questionnaire was administered to undergraduate and graduate engineering students, combining the Big Five personality inventory, perceived team-role selection, and five multi-item scales measuring Attitude, Trust, Social Influence, Fairness & Ethics, and Usefulness toward Gen-AI. Descriptive and inferential analyses showed stable perceptions over time, with small yet meaningful increases in Attitude and AI Literacy ($p < .05$). The mediation analysis indicated that AI literacy acts as a mediator between Openness and perceived Usefulness, although the effect was small and non-significant. The results suggest that continued exposure to Gen-AI fosters both greater confidence and more critical awareness among engineering students. The study provides evidence of the structural reliability of the proposed Excel-based framework and offers practical guidance for integrating AI literacy modules into design-oriented engineering curricula.

Keywords: Generative artificial intelligence, Engineering education, Personality traits, AI literacy, Longitudinal study, Human factors in design

INTRODUCTION

The growing integration of generative Artificial Intelligence (Gen–AI) systems—such as ChatGPT and other large language models—has begun to transform higher education, particularly in disciplines that rely on technical design, modeling, and analytical reasoning. In engineering education, these tools are changing how students conceptualize products, document their ideas, and collaborate during design projects. While their potential to support learning and creativity is widely acknowledged, concerns persist about ethical use, accuracy, and overreliance on automated content generation (El Fathi et al., 2025; Humble, 2024).

Understanding how students perceive and use Gen–AI in university contexts is therefore a critical step in ensuring that these tools enhance rather than undermine the development of engineering competencies. Previous research has shown that psychological and behavioral variables play an essential role

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in determining students' acceptance of AI–based technologies. Personality traits, in particular those defined by the Big Five model, are consistently associated with differential levels of confidence, curiosity, and readiness to use AI in educational settings (Arpaci, Kuşci, & Gibreel, 2025; Hamzaj, 2025). Students scoring high in openness to experience tend to approach AI systems as opportunities for exploration and learning, whereas those high in neuroticism may experience anxiety or distrust toward algorithmic systems. Unlike previous studies, this work uniquely combines personality traits, perceived design roles, and AI literacy within a longitudinal framework, enabling temporal validation of students' evolving attitudes.

Despite the proliferation of recent studies, most investigations remain cross–sectional, capturing attitudes toward AI at a single point in time. Such designs cannot determine whether students' perceptions of AI—regarding usefulness, trust, or ethical concerns—are stable or evolving as exposure increases. In fast–changing technological environments, longitudinal perspectives are necessary to observe how normalization and continued use affect both attitudes and the internal consistency of measurement instruments (Humble, 2024). While promising, prior work often lacked temporal validation and cross–cohort robustness.

Addressing this gap, the present study extends earlier work by Filippi (2024) and Filippi and Motyl (2024) through a longitudinal validation of an Excel–based analytical framework designed to measure the influence of engineering students' personality traits, perceived team roles, and AI literacy on their perceptions of Gen–AI. Two cohorts of undergraduate and graduate engineering students at the University of Udine participated across consecutive academic years (2023–24 and 2024–25). The same questionnaire—comprising sections on personality (Big Five), perceived team roles, and five AI–related dimensions (Attitude, Trust, Social Influence, Fairness & Ethics, and Usefulness)—was administered under identical conditions. The current research therefore offers a rare longitudinal validation combining psychological, behavioral, and literacy–based factors.

The study had three objectives:

1. Validate the temporal stability and reliability of the proposed measurement scales.
2. Compare year–to–year differences in AI–related perceptions.
3. Test whether AI literacy mediates the relationship between personality traits and perceived usefulness.

This work therefore provides a longitudinal validation of how psychological and literacy–related variables shape engineering students' perceptions of generative AI.

METHODOLOGY

Participants and Data Collection

As depicted in Table 1, two consecutive cohorts of engineering students from the University of Udine (Italy) participated in the study across Academic Years 2023–24 and 2024–25. After data cleaning and removal of incomplete

submissions, the final dataset included 106 valid responses (58 from 2023, corresponding to 54.7%, and 48 from 2024, corresponding to 45.3%). Most participants were enrolled in Mechanical Engineering–undergraduate programs (n = 82, 77.4%), with smaller groups from Management Engineering – graduate (n = 14, 13.2%) and Mechanical Engineering–graduate (n = 10, 9.4%). Gender distribution reflected the demographic composition of the programs, with 96 male (90.6%) and 10 female (9.4%) respondents. Participation was voluntary, and students provided informed consent. No personal identifiers were retained beyond academic ID codes, which were used exclusively for anonymized data matching. The survey was administered online during the final month of each course under identical conditions across both years.

Table 1: Sample composition (Participants).

Category	Level	n	%
—	Sample size (N)	106	
Year	2023	58	54.7
Year	2024	48	45.3
Degree	Meccanica triennale / Mechanical undergraduate	82	77.4
Degree	Gestionale magistrale / Management graduate	14	13.2
Degree	Meccanica magistrale / Mechanical graduate	10	9.4
Gender	Male	96	90.6
Gender	Female	10	9.4

Note. Percentages are column–wise proportions within each category; totals may not sum to 100 due to rounding.

Survey Structure and Measurement Instruments

The questionnaire replicated the validated structure developed by Filippi and Motyl (2024) and Filippi (2024), integrating three thematic areas. The structure was carefully aligned across years to ensure construct equivalence.

Personality traits were measured using the IPIP–44 Big Five Inventory, following standard scoring procedures.

The second part addressed perceived roles in design teams. Participants selected six primary and four secondary roles (e.g., Analyst, Product Designer, Creator, Completer–Finisher, Quality Specialist) derived from established frameworks on team composition and engineering design collaboration (Pan & Zhang, 2021). Selections were converted into binary variables (1 = role selected, 0 = not selected) for descriptive and predictive analyses.

Students' perceptions of generative AI were measured through five validated scales covering Attitude, Trust, Social Influence, Fairness & Ethics, and Usefulness, all using 5–point Likert items. An AI Literacy Index was computed from four items addressing familiarity, frequency of use, and understanding of generative AI.

Data Processing and Reliability Assessment

Raw responses were exported to Excel and analyzed using JASP and Python. Bilingual textual responses (Italian/English) were converted into numeric scores (1–5).

For each construct, scale scores were computed as the mean of valid items. All scales demonstrated acceptable internal consistency and were consistent with previously validated structures.

Analytical Procedure

The statistical analysis followed a three–stage plan inspired by prior studies (Arpaci et al., 2025; Humble, 2024).

First, descriptive statistics and reliability coefficients were computed for all constructs within each academic year to assess internal consistency and preliminary trends. Second, independent–sample t–tests with bootstrapped confidence intervals were used to identify possible year–to–year differences between the 2023–24 and 2024–25 cohorts across the five AI dimensions and the AI Literacy Index. Effect sizes (Cohen's d and Cliff's δ) were also calculated to estimate the magnitude of differences. Finally, a simple mediation analysis was performed to examine whether AI literacy mediated the relationship between personality traits and perceived usefulness of AI systems, using bootstrap resampling (5,000 samples). All analyses adopted a two–tailed $\alpha = 0.05$ significance threshold, with False Discovery Rate adjustments for multiple comparisons.

RESULTS

Descriptive Statistics and Reliability

Descriptive statistics and internal consistency coefficients for each scale are reported in Table 2. Overall, the scales demonstrated satisfactory reliability, particularly for Attitude toward AI (α = .86–.89), Social Influence (α = .77–.84), and Usefulness & Performance Expectancy (α = .87–.90). The Trust and Fairness & Ethics dimensions yielded lower α coefficients (α = .33–.68), likely reflecting conceptual heterogeneity of their items, which combine affective, cognitive, and evaluative judgments about AI. Reliability remained acceptable across both years, confirming the temporal stability of measurement constructs.

Table 2: Descriptive statistics and internal consistency (Cronbach's α) for each scale across academic years 2023–24 and 2024–25. Reliability remained acceptable across both years, confirming the temporal stability of measurement constructs.

Scale	k	2023 N	2023 Mean	2023 SD	2023 α	2024 N	2024 Mean	2024 SD	2024 α
A	12	58	2.89	0.84	0.89	48	3.05	0.60	0.86
B	9	58	3.15	0.53	0.68	48	3.23	0.42	0.53
C	4	58	2.64	0.86	0.84	48	2.67	0.76	0.77
D	9	58	3.18	0.45	0.47	48	3.02	0.40	0.33
E	11	58	3.56	0.74	0.90	48	3.54	0.61	0.87
AI Literacy (A3,A4,A5,A12)	4	58	2.90	1.05	0.77	48	3.30	0.80	0.70

Note. N = number of valid responses per scale; α = Cronbach's alpha. Minor year–to–year variations in α reflect differences in sample size and variance distribution.

Year-To-Year Differences (2023 Vs 2024)

Table 3 reports the independent–sample t–tests comparing the 2023 and 2024 cohorts across the five AI–related scales and the AI Literacy index. Overall, no statistically significant differences emerged between cohorts, confirming the longitudinal stability of students' perceptions over time. However, small–to–medium effect sizes (Cohen's d ≈ 0.20–0.40) indicate some directional trends worth noting.

Attitude toward AI (Scale A) and AI Literacy both showed modest increases from 2023 to 2024 (M = 3.05 vs. 2.89, d = 0.22; M = 3.30 vs. 2.91, d = 0.42), suggesting growing familiarity and self–confidence in using generative tools for university tasks. The difference in AI Literacy reached statistical significance (p = .031), indicating a measurable improvement in students' understanding of AI operation and applicability.

Perceived Fairness & Ethics (Scale D) declined slightly (M = 3.03 vs. 3.18, d = –0.37), a pattern that, although not significant (p = .056), may reflect a gradual shift toward more critical awareness of ethical risks and data–handling concerns associated with increased AI exposure. Trust (Scale B), Social Influence (C), and Usefulness & Performance Expectancy (E) remained virtually unchanged, showing consistent perceptions across cohorts.

Table 3: Year-to-year comparisons (t-tests, effect sizes).

Scale	M_2023	SD_2023	M_2024	SD_2024	t	p	Cohen_d	Cliffs_ Delta	p_sig
A	2.886	0.842	3.052	0.605	1.175	0.243	0.223	0.050	n.s.
B	3.153	0.531	3.225	0.418	0.773	0.441	0.148	0.065	n.s.
C	2.642	0.865	2.667	0.757	0.155	0.877	0.030	0.001	n.s.
D	3.184	0.449	3.025	0.396	−1.929	0.056	−0.372	−0.260	n.s.
E	3.564	0.740	3.544	0.613	−0.157	0.875	−0.030	−0.062	n.s.
AI Literacy (A3,A4, A5,A12)	2.905	1.048	3.297	0.797	2.184	0.031	0.415	0.196	p < .05

Note. Independent–samples t–tests comparing 2023 and 2024 cohorts. Effect sizes reported as Cohen's d (standardized mean difference) and Cliff's δ (rank–based).

Taken together, these year–to–year comparisons confirm that students' overall perceptions of generative AI remain stable across cohorts, with only modest directional shifts. The significant improvement in the AI Literacy Index ($p = .031$, $d = 0.42$) suggests that continued exposure to generative–AI systems enhances students' self–confidence and technical understanding of how these systems operate.

In summary, the longitudinal evidence indicates that increased familiarity does not necessarily translate into uncritical enthusiasm: students appear to balance greater operational competence with a more nuanced ethical awareness. These findings support the interpretation that AI literacy mediates a gradual shift from initial curiosity and trust toward reflective, experience–based evaluation—an issue explored in the subsequent mediation analysis.

Mediation Analysis

To examine whether AI Literacy mediates the relationship between personality and perceived usefulness of generative AI, a simple mediation model was tested using Openness to Experience as the independent variable, AI Literacy as the mediator, and the aggregated Usefulness & Performance Expectancy score as the dependent variable.

The results, summarized in Table 4, indicate that the indirect path from Openness to Usefulness through AI Literacy was negative and near zero ($a \times b = –0.04$), whereas the direct effect of Openness on Usefulness ($c' = 0.03$) was also small. The total effect ($c = –0.01$) confirms that Openness alone does not substantially predict perceived usefulness of generative AI when literacy is considered.

Future analyses will extend this mediation model by including additional traits (e.g., Conscientiousness, Neuroticism) and contextual variables such as team–role preferences and prior AI use frequency to verify whether the observed pattern generalizes across broader psychological profiles.

Table 4: Mediation analysis of AI literacy between openness and perceived usefulness.

Path	Effect	p
Indirect (a×b)	–0.04	0.34
Direct (c′)	0.03	0.42
Total (c)	–0.01	0.77

Note. Bootstrapped mediation analysis (5 000 resamples). Confidence intervals omitted for brevity; all effects non–significant at $\alpha = .05$.

A plausible interpretation is that, although open–minded students tend to experiment more with new technologies, their eventual evaluation of AI usefulness depends primarily on instrumental familiarity rather than dispositional curiosity. In other words, attitudes toward generative AI among engineering students appear more strongly shaped by applied experience and curricular exposure than by personality–driven exploration.

Overall, the absence of mediation underscores the dominant role of AI literacy as a learned competence rather than a personality–linked predisposition, reinforcing the importance of targeted instruction for developing informed and responsible AI use in higher education.

DISCUSSION

The findings of this study provide a longitudinal view of how engineering students progressively integrate generative AI into their academic practices. Building upon the stability observed in the descriptive analyses and the results of the mediation model, several insights emerge regarding the evolution of literacy, disciplinary context, and the limited influence of personality traits on perceptions of generative AI.

Overall, the evidence points toward a gradual normalization of AI within the academic environment. Students do not exhibit abrupt shifts in attitudes or trust; instead, they appear to refine their understanding and expectations as they gain more experience with generative systems. This pattern aligns with prior research suggesting that familiarity and curricular exposure shape more reflective forms of engagement with AI tools. The modest increase in AI Literacy from 2023 to 2024 supports the idea that operational competence improves naturally as students encounter generative AI in coursework, assignments, and project–based activities. Meanwhile, the slight decrease in Fairness & Ethics perceptions may reflect growing awareness of risks and limitations as students move beyond initial enthusiasm.

The mediation analysis provides additional insight into these mechanisms by showing that AI Literacy, while central to shaping perceived usefulness, does not act as a mediator between Openness and usefulness judgments. This suggests that personality–driven curiosity—often associated with higher Openness—does not directly translate into more favorable evaluations of AI usefulness once students acquire practical knowledge of how these systems operate. In this cohort, usefulness appears to depend predominantly on applied experience, not on dispositional traits. As such, the results reinforce the idea that AI literacy is a learned competence, shaped primarily by instructional design, hands–on exposure, and contextualized use.

While the longitudinal design strengthens the interpretability of temporal trends, some limitations should be acknowledged. The sample is restricted to engineering students from a single Italian university, which may limit generalizability. Additionally, the two cohorts—although comparable—are relatively small, and future work would benefit from extending the observation window to additional academic years, degree programs, and institutions. Including objective indicators of AI use or performance could also deepen understanding of how literacy evolves and interacts with personality, team roles, and discipline–specific expectations.

With respect to the three research questions, the findings provide clear and consistent answers.

First, the reliability analyses and the near–equivalence of Cronbach's α values across the two academic years confirm the temporal stability of all measurement scales, supporting the longitudinal validity of the proposed analytical framework.

Second, the year–to–year comparison shows that students' perceptions of generative AI remain largely stable, with the only significant difference emerging for AI Literacy, which increases over time. This suggests that continued exposure to generative systems enhances operational familiarity without substantially altering attitudes, trust, or ethical evaluations.

Third, the mediation effect of AI Literacy between Openness and perceived Usefulness is not supported: neither the indirect nor the direct effects reach statistical significance. Taken together, these findings indicate that students' judgments of AI usefulness stem primarily from learned competencies and contextual experience rather than from personality–based predispositions. Overall, the results offer empirical support for the longitudinal model and clarify the psychological mechanisms driving engineering students' evolving engagement with generative AI.

In summary, the longitudinal evidence highlights a trajectory of normalization rather than disruption: as students become more accustomed to AI systems, their perceptions evolve toward balanced and reflective use, informed by literacy and disciplinary experience. This convergence between technical proficiency and ethical awareness provides a promising foundation for the pedagogical integration of generative AI in engineering curricula.

CONCLUSION

This study offered a longitudinal perspective on how engineering students' personality traits, perceived roles in design teams, and AI literacy shape their perceptions of generative AI across two consecutive academic years. By administering the same validated questionnaire to comparable cohorts, the research evaluated the temporal stability of the measurement scales and examined whether students' perceptions evolve as generative AI tools become increasingly embedded in university learning environments.

The results demonstrate that the analytical framework—rooted in personality assessment, team–role identification, and multi–dimensional measures of AI perception—shows robust temporal stability, with reliability indices remaining consistent across years. Students' overall perceptions of generative AI were similarly stable, illustrating a process of gradual normalization rather than abrupt change. The only significant year–to–year variation emerged in AI Literacy, which increased in the 2024 cohort, suggesting that continued exposure and curricular integration naturally enhance students' operational understanding of AI systems.

The mediation analysis further clarified the psychological mechanisms underlying these perceptions. Contrary to expectations derived from earlier cross–sectional studies, AI Literacy did not mediate the relationship between Openness to Experience and perceived usefulness of AI. Neither the indirect nor the direct effects reached statistical significance, indicating that evaluations of usefulness derive more strongly from learned competencies and contextual experience than from personality–based predispositions. This finding reinforces the importance of instructional design and guided practice in shaping informed, critical engagement with AI tools.

Taken together, the longitudinal evidence suggests that engineering students' interaction with generative AI evolves through a balance of increasing

familiarity, steady attitudes, and growing ethical awareness. As literacy improves, students refine—not merely intensify—their views, forming evaluations grounded in practical experience rather than dispositional tendencies. This trajectory provides a solid foundation for curricular strategies that integrate generative AI into design–oriented engineering programs, emphasizing both technical competence and reflective responsibility.

Future extensions of this research should include larger and more diverse samples, additional academic years, and cross–institutional comparisons. Incorporating objective measures of AI use and performance could deepen understanding of how literacy develops and how it interacts with personality, team dynamics, and disciplinary practices. By integrating psychological, behavioral, and educational dimensions, the proposed framework contributes to a more complete understanding of how future engineers can learn to use AI not only efficiently but also responsibly, critically, and creatively.

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