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HUMAN-ROBOT COLLABORATION IN THE WORKPLACE PERCEPTION OF TECHNICAL AND SOCIAL SCIENCE STUDENTS IN POLAND

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Purpose: The article investigates the perception of human-robot collaboration (HRC) in the workplace among students with diverse fields of study (social and technical). The primary objective was to identify differences in attitudes, interests, and emotional responses towards robots, providing insights into their acceptance and future integration into professional environments.
Design/methodology/approach: The research employed a survey-based approach, collecting data from 130 students: 69 from social sciences and 61 from technical fields using the CAWI technique. It focused on analysing students' interest in technology and science fiction, their associations and emotions linked to robots, preferences for robot appearance, and opinions on robot functionality in various contexts.
Findings: The results show some statistically significant differences in the perception of robots and cooperation with robots in the workplace, depending on the field of study.
Research limitations/implications: The study's limitations include its reliance on a survey method, small sample size, and differences in gender participation across the study's fields.
Practical implications: The results suggest that the perceptions of both robots and collaboration in the workplace differ across the groups analysed. This indicates the need for tailored workplace strategies to reduce discomfort and enhance collaboration with robots.
Social implications: The research highlights the importance of functional and user-friendly designs for robot designers and the importance of preparing students for future HRC scenarios through theoretical and practical experiences.
Originality/value: This research sheds light on the connections between education, psychology, and robotics, delving into the constructs related to the perception and acceptance of robots in the workplace and contributing to a broader discourse on factors related to the acceptance and perception of technology by the generation entering the workforce.
Keywords: Human-Robot Collaboration (HRC), Human-Robot Interaction (HRI), robots, workplace robotics.
Category of the paper: Research paper.

1. Introduction

The rapid advancement of robotics and artificial intelligence (AI) has significantly transformed modern workplaces, intensifying interactions between humans and robots. According to the latest *World Robotics* report published by the International Federation of Robotics (IFR) in September 2024, collaborative robots accounted for 10% of robot installations, totalling 57,000 units in 2023 (IFR, 2024). This trend reflects the growing implementation of Industry 4.0 technologies, which pose organizational, technical, and social challenges (Wolniak, 2024). Addressing these challenges requires strategic planning, phased implementation, robust data management systems, comprehensive employee training, and a balanced integration of human and technological capabilities (Wolniak, Tomecki, 2024, p. 634). Recently, the concept of Industry 5.0 has gained prominence in academic and professional discourse, complementing Industry 4.0 by emphasizing the symbiotic relationship between humans and technology (Wieczorek, 2024). Central to this discourse is the concept of human-robot collaboration (HRC), which refers to synergistic partnerships where humans and robots work together toward shared objectives, leveraging human cognitive abilities alongside robotic precision and efficiency. HRC has the potential to enhance productivity, safety, and work quality, yet its effectiveness depends on both technological capabilities and human attitudes toward working with robots (Ruffaldi et al., 2023). Achieving seamless human-robot collaboration requires improved team performance and fostering positive perceptions of both the robots and the collaborative process (Noormohammadi-Asl et al., 2025).

This paper aims to explore students' perceptions of robots and their potential collaboration in the workplace, focusing on social and technical disciplines. Specifically, it seeks to identify differences in attitudes, interests, and emotional reactions toward robots, offering insights into their acceptance and potential integration into professional environments. The study's research question examines whether students' field of study significantly influences their responses. The selected research group—students from social and technical disciplines—provides a compelling sample due to their contrasting educational and professional perspectives. While technical students typically possess greater familiarity with technology, potentially fostering openness and trust in robotics, social students may emphasize ethical and societal implications, offering valuable insights into the broader impacts of robotics on interpersonal relationships.

2. Human-robot interaction and collaboration in workplace

The integration of robots into the workplace has advanced significantly in recent years, mainly due to technological advances in robotics and artificial intelligence (AI). Human-robot interaction (HRI) focuses on communication and collaboration between humans and robots to improve functionality and user experience. Human-robot collaboration is a specific type of interaction in which tasks outside a shared workspace are performed jointly with direct physical contact and context awareness, distinguishing it from coexistence and collaboration (Jahanmahin et al., 2022). Collaborative robots, or cobots, are designed to work alongside humans in a variety of tasks, from manufacturing to healthcare (Colgate et al., 1996; Villani et al., 2018). Studies have shown that effective HRI depends on factors such as trust, perceived usefulness, and the ability of robots to adapt to human needs. Hancock et al. (2011) conducted a meta-analysis highlighting trust as a critical factor in successful collaboration. They found that the predictability and transparency of robot actions are crucial for building trust and increasing productivity and safety in collaborative tasks. Robots as intermediaries in work processes can also represent a new dimension of differentiation of labour resources. This leads to a new area of human and humanoid resource management. A new organizational culture is emerging to which robots belong (Rakowska, 2022a). In manufacturing, collaborative robots are widely used to increase efficiency and reduce the physical burden on workers. For example, robots designed by Universal Robots have been integrated into automotive assembly lines, where they perform repetitive tasks, while humans focus on quality control and complex decision-making (Weiss et al., 2021). This division of labour illustrates the potential of symbiotic human-robot collaboration. Healthcare is another field in which HRI plays a key role. Robots like the da Vinci Surgical System have revolutionized minimally invasive surgery, providing greater precision and reducing surgeon fatigue (Calo et al., 2011). Furthermore, robots such as PARO, a therapeutic robot designed to assist in the care of the elderly, have demonstrated the importance of emotional interaction in healthcare settings (Wada et al., 2007).

Despite these advances, challenges remain. One key issue is the “valley of anxiety” phenomenon, where robots that are too human cause discomfort among users (Mori et al., 2012). Appel et al. (2020) emphasized that robots should balance functionality and appearance to ensure acceptance in the workplace. This is because employees are one of the key factors for the successful implementation of robots in organizations. This emphasizes the importance of understanding how the human characteristics of robots affect employee interaction and acceptance (Rakowska, 2022b). In addition, ethical concerns such as job replacement and data privacy remain significant barriers to widespread adoption (Brynjolfsson, McAfee, 2014). Future developments in HRI aim to address these challenges by focusing on adaptive algorithms, intuitive interfaces, and user-centred designs. Villani et al. (2018) argue that interdisciplinary research combining engineering, psychology, and ergonomics is essential to creating robots that integrate seamlessly into various work environments.

3. Materials and Methods

This study aimed to identify students' perceptions of robots and their potential collaboration with robots in the workplace. The central research question was: To what extent does the field of study influence perceptions of robots and the willingness to collaborate with them in professional settings? To address this question and achieve the research objectives, a quantitative study was conducted in March and April 2023 using the Computer-Assisted Web Interviewing (CAWI) technique.

The online survey involved 130 participants, consisting of 69 students from social science disciplines (e.g., logistics, management, economics, economic analysis, finance and accounting, and psychology) and 61 students from technical fields (e.g., automation, robotics, computer science, mechanical engineering, energy, mechatronics, transport, electronics, and telecommunications). Participants were recruited through targeted outreach to academic groups and segmented based on their fields of study, ensuring alignment with the study's objectives and assumptions. Participants received a link to the survey via email and university communication channels. The survey was anonymous, and informed consent was obtained electronically before participation. Respondents were assured that their data would be used solely for academic purposes and handled in compliance with ethical research standards.

The primary data collection instrument was a custom-designed online questionnaire based on a review of existing literature on perceptions of robots (Piçarra et al., 2016; Giger et al., 2017; Riek et al., 2011; Goetz et al., 2003; Wasilewska, Łupkowski, 2021) and the field of human-robot interaction (e.g. Koverola et al., 2022). The survey instrument consisted of 20 questions containing Likert-scale items ranging from 1 (strongly disagree) to 7 (strongly agree) and multiple-choice and open-ended questions to obtain qualitative insights into emotions and associations with robots. In the structure of the research tool, we can distinguish the following areas:

- perceptions of robots: associations (e.g., "future", "technology", "helper"), emotions, interest in new technologies and the science fiction genre,
- interaction preferences: Questions on preferred robot designs (appearance) for different contexts, e.g., collaboration or customer service,
- attitudes toward workplace collaboration with robots: Assess trust, perceived usefulness, and discomfort in interacting with robots (physical contact, communication, joint tasks, and workspace sharing with the robot),
- sociodemographic information: gender, course and year of study, professional status.

Data analysis was conducted using statistical software- SPSS and Orange Data Mining. Descriptive statistics, such as means, medians, and standard deviations, were computed for Likert-scale items to summarize the data. Chi-square tests were applied to categorical data to assess the relationships between the study field and categorical responses. Mann-Whitney U tests were employed for ordinal data (Likert-scale items) to compare responses between the two student groups. A significance threshold of $p < 0.05$ was used to determine statistical significance differences between groups. The results were checked for reliability and validity to ensure robustness.

4. Results

The sample included 130 participants, with 69 students from social sciences and 61 from technical sciences (Table 1). Gender distribution varied, with a higher proportion of females in the social sciences group (81.13%) compared to the technical sciences group (18.87%), which had a more balanced gender representation. The majority of participants were undergraduate students, and a smaller subset was employed part-time or full-time.

Table 1.
Sociodemographic data of the respondents

Characteristic	Answers	N	%
Gender	Female	53	40.80%
	Male	76	58.50%
	I do not want to answer	1	0.80%
	Total	130	100.00%
Level of study	First degree	77	59.20%
	Second degree	53	40.80%
	Total	130	100.00%
Field of study	Social field (e.g. Logistics, Management, Economics, Business analysis, Finance and Accounting)	69	53.10%
	Technical field (e.g. Automation, Robotics, Computer science, Mechanics and Machine construction, Energy, Mechatronics, Transport, Electronics and Telecommunications)	61	46.90%
	Total	130	100.00%
Professional status	Studying	75	57.70%
	Studying and working	55	42.30%
	Total	130	100.00%

Source: own elaboration based on conducted research.

Moving to the part of the research results related to robot perception, the interest in new technologies and the science fiction genre was examined, as well as emotions and associations with the word robot. Students from technical sciences reported a significantly higher interest in new technologies (mean = 5.90) compared to their social science counterparts (mean = 5.09), with a Mann-Whitney U test confirming statistical significance ($U = 1228$, $p < .001$). Similarly, interest in science fiction was higher among technical students (mean = 5.08) than social science students (mean = 4.32), also statistically significant (U = 1560.5, p = .01). When analysing associations with the word "robot," students collectively provided 328 associations. The most frequently mentioned association was technology, which appeared 102 times (social sciences students: 56, technical students: 46). Future was indicated 66 times (social sciences students: 33, technical students: 33), while new opportunities was mentioned 55 times (social sciences students: 26, technical students: 29). Social sciences students significantly more often associated robots with toys ($\chi^2 = 4.485$, $p = .034$) and household help ($\chi^2 = 4.617$, $p = .032$) compared to technical students. All associations from social sciences students (right) and technical students (left) were visualized as word clouds (Figure 1), where the size of each word represents the frequency of the given response.

Figure 1. Word clouds of the associated with robots.

Source: own elaboration based on conducted research.

Among social sciences students, 110 instances of positive emotions were recorded (including enthusiasm, fascination, and interest), along with 63 instances of negative emotions (including anxiety, uncertainty, fear, terror, stress, and anger). Technical students reported more than 2.3 times fewer negative emotions compared to social sciences students and indicated 20 more instances of positive emotions, despite having fewer overall responses within this group. Statistical analysis revealed significant differences in emotional responses between groups (e.g., entusiasm: $\chi2 = 20.43$, $p < .001$, fear: $\chi2 = 4.056$, $p = .044$, uncertainty: $\chi2 = 13.416$, $p < .001$). All emotions were visualized as word clouds (Figure 2), where the size of each word represents the frequency of the given response.

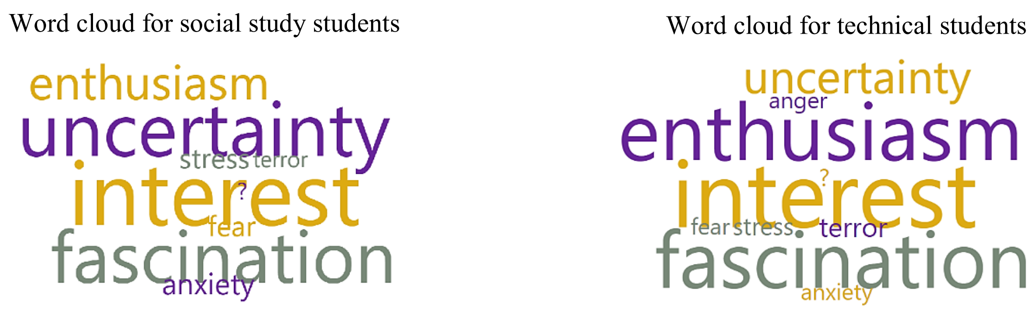

Figure 2. Word clouds of the emotions with robots.

Source: own elaboration based on conducted research.

The next section of the results discusses aspects related to interaction preferences in the willingness to work and be operated by a robot focused on the robot design. To investigate robot appearance preferences, students were shown images of the following robots: „Carindinal" Amazon; „BellaBot" Pudu; "Moxi" Diligent Robots, "Atlas" Boston Dynamics; "Ameca" Engineered Arts; "Sophia" Hanson Robotics. The indicated robots differed in their construction and humanoidity. Both groups showed a preference for non-humanoid robots for workplace tasks. However, technical students were more open to humanoid robots with mechanical features ("Ameca" Engineered Arts), while social science students preferred designs that incorporated friendly or familiar aesthetics, such as screen-based faces („BellaBot" Pudu) ($\chi 2 = 30.416$, $p < .001$). The most favoured robot for interaction (as a client) was "BellaBot," likely influenced by its appearance and prior exposure in commercial settings. The most negative experiences and ratings in all contexts were obtained by the Hanson Robotics robot "Sophia", which is a robot with a high level of humanoidness.

The last area of focus in the research findings involves attitudes toward workplace collaboration with robots. The focus was in particular on assess trust, perceived usefulness, and discomfort in interacting with robots (physical contact, communication, joint tasks, and workspace sharing with the robot). Social science students expressed greater discomfort with sharing a workspace or directly interacting with robots (mean discomfort = 3.84) compared to technical students (mean discomfort = 2.98). Similarly, social science students were more skeptical about robots replacing human jobs or contributing positively to workplace dynamics. This may result from a higher sense of human irreplaceability - the perception of the uniqueness of human nature. Mann-Whitney U test confirmed significant associations between field of study and responses to key survey items, including

- discomfort with direct robot interaction: direct cooperation with the robot (physical contact, communication) ($U = 1271.5$, $p < .001$) and sharing workspace with a robot (safety, psychological comfort) ($U = 1518.5$, $p < .006$),
- positive perception of robot utility in handling routine tasks ($U = 1441.5$, $p < .001$).

In summary, the findings presented in this section indicate that interests and the chosen field of study may be an important factor in differentiating perception of robots.

5. Disscusion

The results of this study provide important insights into how technical and social science students perceive human-robot collaboration (HRC) in the workplace. The observed differences in attitudes, interests and emotional reactions towards robots highlight the role of education in shaping perceptions of robotic technology. Looking at the literature, it is clear that these results are not inconsistent with the observations of researchers working on human-robot interactions and perceptions of robots, including various studies conducted, for example, by Giger (Giger et al., 2017a, 2017b), Nomura (Nomura et al., 2006; Nomura, 2014), Piçarra (Piçarra et al., 2016a; 2016b), Groom (Groom et al., 2009) or Mori, MacDorman, Kageki (Mori, MacDorman, Kageki, 2012).

Giger, Moura, Almeida, and Piçarra's research found that individuals with a greater interest in science fiction tend to have more positive attitudes toward robots, likely due to their familiarity with depictions of robots and futuristic scenarios (Giger et al., 2017a; 2017b). This finding aligns with the results of the present study, where students who showed a significantly higher interest in the science fiction genre and technological development—particularly engineering students—expressed more positive attitudes toward robots and collaboration with them. In addition, empirical research suggests that direct (but also virtual) exposure to robots can significantly shape individuals’ attitudes toward human-robot interactions. Nomura, Suzuki, Kanda, Kato’s (2006) and later Nomura's (2014) study found that individuals who had previously observed real robots in action or through media showed less negativity toward interactions with them than individuals who had not had such experiences. The specificity of technical fields of study may increase the opportunities for direct exposure and interaction with robots during studies, compared to social students, which may also influence the level of acceptance and the formation of a more positive attitude towards robots. Research by Piçarry et al. (2016a; 2016b) indicated that associations and pre-existing images of robots influence the perception of their functionality and role in different contexts. The associations (images) obtained in the study differed by the field of study - technical students indicated an industrial and technological context, while social students indicated an everyday context (home help). This was reflected in the indicated emotions and perceived functionality of the robots.

Groom et al.'s (2009) study found that more anthropomorphic robots received more positive ratings overall compared to purely functional ones. However, excessive human resemblance can lead to discomfort, as described in the "valley of anxiety" phenomenon (Mori, MacDorman, Kageki, 2012). This is consistent with results obtained with Polish students, in which participants showed a dislike for highly human-like robots, while preferring designs that strike a balance between familiarity and mechanical aesthetics.

6. Conclusion

The key findings revealed that technical students showed greater interest in new technologies and science fiction, along with lower discomfort levels regarding direct collaboration with robots. Both groups preferred robots with moderate humanoid features, avoiding highly human-like designs. Social science students viewed robots primarily as tools to handle routine tasks, whereas technical students emphasized their functional utility. Emotional responses differed significantly, with technical students expressing more positive emotions. Both groups demonstrated limited willingness to engage with highly humanoid robots, favoring simpler designs with suggestive facial features like screens.

The scope of this study does not fully encompass all issues related to the factors influencing perceptions and attitudes toward robots, nor does it address the entire concept of Human-Robot Interaction (HRI) and Human-Robot Collaboration (HRC). Future research could benefit from incorporating additional variables for analysis, such as age, nationality, different fields of study, or aspects related to the perception of human uniqueness. To this end, qualitative research methods, such as interviews or individual case studies, as well as experiments involving direct interaction with robots, could be employed to provide a more in-depth characterization of attitudes toward these issues. The study's findings provide valuable insights for management professionals, robot designers, and academic educators. They demonstrate that differing perceptions of robots and potential collaboration require appropriate introduction and adaptation of young employees, thoughtful robot design (e.g., appearance that reduces feelings of discomfort), and adequate theoretical preparation (grounded in academic knowledge) concerning the capabilities and interactions with robots.

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