TPM Vol. 32, No. S4, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

PSYCHOLOGICAL PROFILING OF ROBOTICS ENGINEERS BASED ON INNOVATION AND COGNITIVE FLEXIBILITY

DR. VIVEK MALIK[1], DR.RAJVIR SAINI[2], DR. MAHIMA GULATI[3]
[1]ASSISTANT PROFESSOR, KALINGA UNIVERSITY, RAIPUR, INDIA.
[2]ASSISTANT PROFESSOR, KALINGA UNIVERSITY, RAIPUR, INDIA.
email: ku.rajvirsaini@kalingauniversity.ac.in ORCID: 0009-0000-6644-0795
[3]ASSISTANT PROFESSOR, NEW DELHI INSTITUTE OF MANAGEMENT, NEW DELHI, INDIA.,
e-mail: mahima.gulati@ndimdelhi.org, https://orcid.org/0000-0003-3504-8074

Abstract
In the highly evolving field of robotics engineering, invention cannot be attributed strictly to technical skill, but is based on the cognitive and behavioural makeup of the engineers themselves. This study examines the different types of cognitive and behavioural profile of robotics engineers, especially cognitive flexibility - the adaptability of thought - and how this applies to innovators. People involved in developing robotics continue to push the cognitive complexity of robots, and yet little is known about the cognitive diversity of those creating these systems. This study seeks to identify psychological profiles that distinguish engineers who are creative problem-solvers from those who are technical executors.This study employed a mixed-method design, incorporating various psychometric measures (Cognitive Flexibility Inventory / Innovation Behaviour Scale), combining these with qualitative think-aloud and situational judgment outcome scenarios. The sample of robotics engineers included students, academics, industry and research engineers, including career guidance. The breadth of experience and specialization was wide-ranging.The initial findings infer the existence of psychologically different clusters, for example "flexible innovators" and "disciplined executors," with their own cognitive styles and tendency or ability to innovate. The findings provide a novel understanding of the contribution of psychological flexibility to innovation in engineering. As well when considering what talent development, team development, and cognitive recruitment may imply.
Keywords: Cognitive Flexibility, Innovation Behaviour, Psychological Profiling, Robotics Engineers, Engineering Psychology, Creative Problem Solving, Cognitive Traits, Technical Creativity, Adaptive Thinking, Human Factors in Engineering

I. INTRODUCTION

As robotic systems become more autonomous, intelligent, and integrated into society, the psychological attributes of the engineers who create robotics systems become an important albeit underdeveloped aspect of innovation. In advanced technologies, success is based on technological proficiency and human attributes such as flexibility, creativity, and cognitive activity. These human attributes influence how engineers frame, conceptualize, ideate, and solve problems. However, engineering psychologyespecially the psychology of engineers involved in roboticsremains a largely unexplored field. Groups of researchers in education and workplace psychology have developed profiles of cognitive traits, but the actual cognitive dynamics associated with why engineers build innovative robotic systems have received little attention yet are important to understand. This study seeks to understand the cognitive traits engineers possess, specifically cognitive flexibility, to better understand how cognitive traits interact with design behaviour in robotics engineers, and whether we can define different psychological profiles in engineers that may correspond to their potential for innovation as engineers. Understanding the cognitive traits in engineers would be useful when considering individual performance, team roles, training opportunities, and hiring practices in technological settings. By integrating engineering with psychology, we can open new doors to develop human minds that develop robotic systems that may define our future.

II. MENTAL MODELS THAT DRIVE DESIGN

Innovation is frequently described in engineering as the ability to create novel, effective, and appropriate solutions to complex dilemmas. From a psychological perspective, innovation is a process, not simply a behaviour, that can be defined as a product of various cognitive characteristics, primarily cognitive flexibility, which is the mental capability to rapidly shift perspectives, strategy, and application of information in a situational context. Cognitive flexibility is primarily related to executive functioning, particularly in the areas of learning new information, task-switching, and redefining problems. Further to this, within the Five-Factor Model of personality, openness to experiencing and conscientiousness have been established as personality attributes that produce greater innovation potential within people. Psychologists have found ways to operate with ambiguity, explore oppositional views, and develop potentialitiesall of which allow individuals to explore the unknown and turn away from traditional or habitual thinking styles, even within complex iterative and uncertain processes, like the design of robotic systems. In engineering psychology, adaptability to pressure and making decisions under constraints are vital components in the performance of real-world contexts. Prior research in the STEM fields have engaged in psychological profiling in computer science, aeronautics and design engineering, identifying profiles that distinguish between conceptual thinkers and action-oriented operatives. In particular, the creative disciplines of architectural and game design, where individual profiles who embraced flexibility and adopted divergent thinking, were more successful at completing ill-structured, complex design tasks. This study derives from similar profiles exist in robotics engineering and how they influence innovation outcomes.

III. WHO CONSTRUCTS, WHO INNOVATES? PSYCHOLOGICAL TRAITS AND PSYCHOLOGICAL PROFILES

Robotic engineers work at the intersection of reality and possibility; it is the space between mechanical sense and design imagination. The technical skill aspect of engineering is fundamental and necessary, typically psychological characteristics distinguish those who build from those who innovate. For example, common characteristics present among robotics engineers are high levels of analytical reasoning, great attention to detail, and systematic abilities to troubleshoot different destructive forces in engineering systems. However, within robotics engineering fields, innovators will have cognitive flexibility, intrinsic motivation, and creative risk-taking. They also have the skills to break free from standard protocols and explore novel solutions.

Motivation is equally important in innovation, as curiosities and purpose of engineers are going to lead them to push constraints and act as explorative. Cognitive flexibility as a construct, can help analyze any motivators/constraints, as an individual with cognitive flexibility can switch perspectives, reframe problems and face technological uncertainties. Cognitive flexibility within the robotics innovator is critical for iterative prototyping and transdisciplinary collaboration. Creative problem solvers are divergent thinkers that are comfortable, or tolerant of ambiguity, whereas implementers are converges or sequential logic thinkers, and value logical procedures.

The preliminary profiling dimensions that emerged in robotics contexts identified two cognitive archetypes: analytical thinkers - who thrive in areas of structured problem space, and adaptive thinkers - who thrive in spaces that are more rapidly evolving or undefined; a similar distinction can be made between innovators, who initiate conceptual break-throughs, and implementers - who take ideas and make them practical, and refine them. Knowing the psychological diversity in engineering teams can yield previously hidden insights and can provide an opportunity for a more strategic role in the design of projects and the management of innovation.

IV. THOUGHT TO DATA (PROFILING)

In order to explore the psychological characteristics that promote innovation in the discipline of robotics engineering, a multi-method profiling methodology was used. The sample contained 48 robotics engineers from various fields including autonomous systems, industrial automation, biomedical robotics, and robotics that involved artificial intelligence. Participants provided varying levels of experience, from final year graduate students to senior level engineers with a bulk of their experience being greater than 10 years. This variance in background allowed a comparative profile across different cognitive and professional levels.

Three basic approaches to operationalizing the core constructs will be utilized:

- Cognitive Flexibility Inventory (CFI): a measure of adaptability of thinking to changing task demands resulting in a changed cognitive strategy.
- Innovation Behaviour Scale: a self-assessment of behaviours including creativity, risk-taking, idea generation, and willingness to experiment.

- Divergent Thinking Task (tailored for robotics) and a Situational Judgment Test (SJT). Engineering scenarios will be included for participants to respond in real-time while performing a task. These assessment tools were established to assess flexibility under constraints, novelty in approach, and the capacity to make effective real-time decisions.

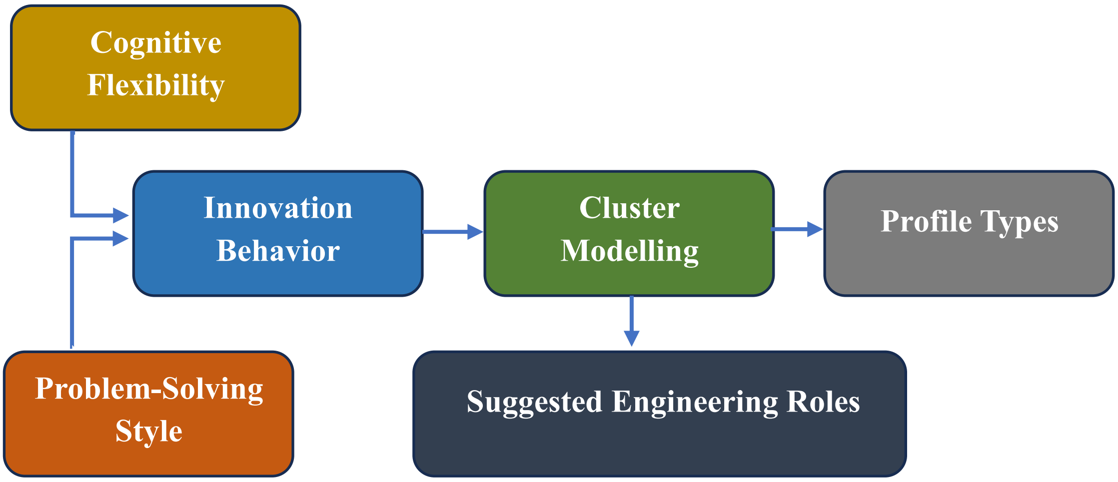

Figure 1: Cognitive Traits to Role Profiles

Figure 1 depicts how raw psychological data can be systematically transformed into useful role profiles from an engineering perspective. The process starts with measuring the essential cognitive traitscognitive flexibility, innovation behaviour, and problem-solving style. These traits are measured using validated psychometric instruments and structured tasks. Once the data is collected, we use cluster modelling techniques to identify patterns that emerge across the participants. These patterns help inform psychological profiles such as Flexible Innovator, Disciplined Executor and Creative Specialist. Each of these is a combination of cognitive and behavioural traits, which is particularly relevant in an engineering design context. The last step is to map the profiles to recommended roles in robotics teams, aligning psychological traits with project demands. This diagram provides a way to translate abstract cognitive data into useful uses for human resources, team design, and innovation strategy. It also provides a pathway to utilize human concepts that serve to bridge psychology and the practice of engineering; it provides a systematic understanding of the human architecture as an embedded system in technological systems.
Collection of data will follow a two-phased approach: the first phase will be a survey session including the psychometrics measuring profession and playwright traits. The second phase will be task-based session that will capture think-aloud protocols, scenario responses, and semi-structured interviews. Participants will receive briefing on the scope of the study and informed consent forms to sign prior to data collection. The psychological research review board supported by the host institution provided ethical approval for the study. Importantly, anonymity, participation by choice, and ensuring psychological safety are ethical considerations taken seriously throughout this study process.

V. TYPOLOGY OF TINKERERS (DATA ANALYSIS AND DEVELOPING PROFILES)

5.1. Mapping the Mental Clusters

In order to uncover the psychological diversity within robotics engineering, a cluster analysis was performed using composite scores for the Cognitive Flexibility Inventory, Innovation Behaviour Scale, as well as scores on divergent thinking tasks through a multivariate approach. The analysis yielded a three-profile arrangement, which uniquely separated engineers with respect to an underlying cognitive and creative style, rather than solely differentiating on technical skill.

Table 1: Cognitive Profile Matrix of Robotics Engineers

Profile Name	Cognitive Flexibility	Innovation Behavior	Design Style	Strengths	Ideal Role
Flexible Innovator	High	High	Exploratory & adaptive	Rapid ideation, agile problem-solving	Conceptual Design, R&D
Disciplined Executor	Low to Moderate	Moderate	Structured & detail-driven	Procedural accuracy, system refinement	Implementation, QA/Testing
Creative Specialist	Moderate	High	Domain-specific creative	Niche innovation, intuitive design	Interface Design, Special Projects

Table 1 depicts0020the heart of your paper because it summarises the psychological profiles - the main outcome of your research. It distills a range of statistical analyses into a simple structure to express who the engineers are cognitively and behaviourally. Without it, readers may fail to visualize the applied meaning of your profiling outcomes.

5.2. Profiles in Practice

Flexible Innovators: This profile could easily be distinguished based on the high scores they received in cognitive flexibility and innovation behaviour scores. They would adapt well, exhibit openness to new ideas and were adept at pivoting on approaches to more complex design contexts best where tasks were not structured. They often suggested unique yet legitimate responses to requests and had the ability to explore lines of thinking in formulation or iteration, making them ideal for early-stage idea generation and disruptive innovation.

Disciplined Executors: This profile (compared to the first) presented relatively low to moderate flexibility but moderate to high consistency and where focus is important in a structured environment. While they would not be great generators of ideas, they were great at honing in and executing ideas in a precise manner. Their best cognitive style was convergent thinking apt for applying and standardizing decision making, with strong systematic problem solving under uncertainty; thus, their roles and decisions were highly relevant for standardization, optimization, and the execution stage of engineering projects.

Creative Specialists: Driving high creative output and flexibility at moderate levels, these engineers operated within specific domains where depth of expertise and ideas intersect, such as in user-interface robotics, or education robots or robotic art. They generally preferred visual-spatial work and had the greatest success when provided domain-specific freedom.

The analysis indicates a clear cognitive difference represented by the flexibility of robotics teams across innovation potential. High flexibility engineers were more likely to confront assumptions and change designs rapidly; while low flexible engineers delivered best with defined goals and consistency. These profiles can be used to provide insights regarding team formation, workload distribution, and innovation support in advantageously complex technological settings.

VI. INTERPRETATION AND IMPLICATIONS

The psychological profiles developed in this study offer significant insights about how cognitive diversity contributes to innovation in robotics engineering teams. The Flexible Innovators are a valuable asset in both the ideation stage and early rapid prototyping and in situations where design is mostly unclear. They are essential in environments requiring rapid iteration of ideation to production. The Disciplined Executors role is critical where precise and stable delivery of plan implementation is paramount. Attention to detail, fidelity to a process, and refinement and improvement are determined characteristics that lead constructions of innovative ideas to functional reality. The Creative Specialists, on the other hand, were also favourable.

These differences should be considered carefully when it comes to team structure and hiring. For example, it could be advantageous for engineering leaders to match cognitive profiles with the various phases of workthe flexible thinkers focused on exploration and the disciplined thinkers on refinement. When hiring engineers, it could be meaningful to use cognitive assessments to ensure balanced team dynamics, while also reducing likelihood of cognitive redundancy.

In engaging with engineering students, the shift to cognitive flexibility can be achieved by providing open-ended and collaborative problem-solving, purposeful cross-discipline collaboration, and exposure to creativity programs. Doing so provides unique learning experiences to develop cognitive flexibility – having their graduates prepared to innovate. To summarize this idea - profile diversity and understanding how to leverage it can strengthen collaboration across functions - each of the roles such as idea makers, system refiners and domain specific creatives can create synergies each in different ways to promote technological progress.

VII. CONCLUSION

This study aimed to investigate the psychological profiles of robotics engineers, with a focus on the interplay between cognitive flexibility and innovation behaviour. By delving deeper than simply identifying surface-level skills to the mental architectures that aid design thinking, the study demonstrated how the cognitive styles of robotics engineers yield different formats of cognitive contributions to robotics development. Cluster analysis revealed three psychological profiles: Flexible Innovators, Disciplined Executors, and Creative Specialists, in each the limited cognitive contributing aspects of their design. These findings strongly suggest that psychological profiling is useful in supporting high-tech fields where product innovation depends on not only technical skills, but also mental flexibility, adaptability, and imaginative ingenuity of the individual engineers. Recognizing and applying these psychological profiles when hiring, developing teams, or employing leadership styles may significantly impact both productivity and the rate of innovative outcomes.In future research, it would be interesting to explore a longitudinal design that would track how these profiles might shift over-time and how different profiles react and adapt to varying project pressures. Research is just beginning to examine the dynamics of AI-human co-design and how.ai tools might gate collaborations and different psychological types. There is also emerging promise in convening emotional-cognitive dimensions (e.g. resilience, empathy, stress response) together with ideals to further enhance profiling models and to gain a far more coordinates understanding of the cognitive minds who generate technologies.

REFERENCES

Fares, S. A. (2025). Federated meta-learning for privacy-preserving AI in smart home ecosystems. Electronics, Communications, and Computing Summit, 3(1), 42–51.

Pieter, J., Setyawati, S. M., & Setyanto, R. P. (2025). The Role of Value Resonance Efficacy to Decrease Intention to Buy Counterfeit Product. Quality-Access to Success, 26(205).

Poornimadarshini, S. (2025). Mathematical modeling of rotor dynamics in high-speed electric motors for aerospace applications. Journal of Applied Mathematical Models in Engineering, 1(1), 33–43.