AN INTEGRATED RECIPROCAL HUMAN AI SOCIO-TECHNICAL FRAMEWORK: ENHANCING CREATIVE SYNERGY IN CROWDSOURCED DESIGN

WARDI, R. H.[1*] – KHALID, K.[2] – ANWAR, R.[1] – NASER, F. L.[1]

[1] *College of Creative Arts, Universiti Teknologi MARA (UiTM), Selangor, Malaysia.*

[2] *College of Engineering, Universiti Teknologi MARA (UiTM) Pahang Branch, Pahang, Malaysia.*

**Corresponding author*
e-mail: rainzwar[at]uitm.edu.my

(Received 03rd May 2025; revised 30th July 2025; accepted 07th August 2025)

Abstract. This concept paper discusses the Integrated Reciprocal Human-AI Socio-Technical Framework, which integrates artificial intelligence (AI) automation with human creativity in crowdsourced design settings. Although AI systems contribute to the efficiency of the design, their scalability, and automation of the tasks, their increasing monopoly poses the risk of rendering human intuition, creative autonomy, and ethical control unimportant. The framework suggested will be based on Reciprocal Human-Machine Learning (RHML), in which dynamic, two-way learning between human designers and AI systems will be facilitated. Two important mediating constructs, Polanyi Paradox and Algorithm Aversion, underline the incomparability of the tacit human knowledge and the significance of transparency and trust in the relations between humans and AI. Ethics can be considered as a balancing force, which guarantees equity, protection of intellectual property, and open business in the design process. All these elements are meant to create a creative synergy state, in which AI does not substitute the functions of human creativity but supplements them. The framework focuses on the key gaps in the current AI-based design systems because it focuses on the outcomes of the collaboration between humans and AI systems instead of the automation-based results. It is suggested that future studies empirically support the framework by using qualitative research that will involve creative professionals working on AI-supported platforms. The paper will add a sustainable, ethically-based roadmap of how to incorporate AI in collaborative creative work without sacrificing human uniqueness or agency.
Keywords: *crowdsourced design, AI automation, human intuition, Reciprocal Human-Machine Learning (RHML), algorithm aversion*

Introduction

The Artificial Intelligence technology enhances the speed and scalability of design crowdsourcing platforms. The overuse of this technology causes issues concerning the adverse effects on creative abilities and human instinctive judgments. Instead of taking away the designing capabilities of designers, artificial intelligence must supplement their capabilities to keep the creative processes intact. The use of AI-based systems creates algorithmic problems that minimize the role of experts and introduce ethical ambiguities, which require human and technological design approaches. The crowdsourced design approach has become the most popular method in various fields of work, as it enables parties involved to collaborate in providing innovative solutions (Brabham, 2008). Quicker workflows in design and increased capacity of AI systems lead to two design issues, which can be symbolized by the automation enabled by computers and the decrease in the role played by expert human designers (Kittur et al., 2013). Socio-technical systems facilitate innovative decision-making by defining the boundaries of AI concerning human capacity to think and encourage co-work rather

than the substitution of human designers. Socio-technical systems integrate the aspects of technology and social systems to preserve human values and social structures during technological development, thereby enhancing the design process (Baxter and Sommerville, 2011). The role of AI in the decision-making process is to assist in the design of creativity without restricting people from fully controlling the complex problem-solving process and aesthetic judgment (Shneiderman, 2020). The mechanism of crowdsourced design must develop an organized interface between artificial intelligence automation and the human creative decision-making.

Educational studies on AI automation design focus on its beneficial outcomes and potential harmful side effects, which can limit human creativity and decision-making power. Shneiderman (2020) has explored human-centric AI and algorithmic management in crowdsourced platforms, drawing on the accounts of Rosenblat and Stark (2016) as well as Irani (2015). However, there is a big gap in knowledge regarding the creation of AI systems that facilitate human creativity rather than displacing it. The existing literature lacks a comprehensive socio-technical solution that balances the automation of AI with human intuition, possessing high ethical characteristics of fairness, explainability, and trustworthiness. The design tools of the platform, such as Amazon Mechanical Turk and OpenIDEO, are based on an algorithm-driven system of task distribution that significantly reduces the level of worker autonomy. These systems establish rigid and computational work patterns that limit users' ability to exercise self-control (Kittur et al., 2013). In such circumstances, human employees are often solicited to complete tasks of low autonomy and repetitive nature that are regulated by algorithms and further compounded by excessive automation (Rosenblat and Stark, 2016; Irani, 2015).

Similarly, creative work can be automated with the aid of AI-based design tools, such as Adobe Sensei, which utilize statistical pattern recognition. Despite the efficiency this brings, it often leads to standardized outputs that constrain the variety and innovation of design solutions (Kittur et al., 2013). It is necessary to integrate explainable AI (XAI) systems and adaptive workflows to bridge the gap between designers and AI technologies, thereby preserving creative freedom (Starbird, 2019). Ethical guidelines should accompany the use of AI in crowdsourcing systems to ensure fair payment and recognition of human workers, thereby eliminating invisible forms of labor (Crawford, 2021; Irani, 2015). The crowdsourcing design platform achieves its optimal level of operational efficiency and creative thinking by combining artificial intelligence automation with human intuition. The use of artificial intelligence in crowdsourced design has significantly enhanced the efficiency of operations, scalability of the system, and automation. Advances in technology raise serious concerns about the loss of human-initiated creativity, freedom in decision-making, and ethical decision-making processes. Existing AI-based solutions to crowdsourced design are primarily aimed at ensuring the highest possible computational efficiency and automation, which, however, can undermine human intuition, lead to self-destructive processes, and result in unjust decision-making. The work of AI systems is based on the existence of a preset framework to produce decisions, but they are supposed to augment human potential.

Earlier studies on Human-Centered Artificial Intelligence (HCAI) and algorithmic management face serious challenges in identifying the proper AI support measures that do not compromise human creative skills in crowdsourced design. Recent studies are examining the AI improvement of workflow allocation and effectiveness. It has, however, failed to develop a comprehensive socio-technical approach to establish trust

mechanisms and provide unambiguous explanations for the collaboration between humans and AIs. AI systems cannot understand the Polanyi Paradox and Algorithm Aversion, as they do not possess much tacit knowledge, and people do not trust their results. The loopholes in digital design processes lead to reduced sustainable and ethical activities, resulting in a loss of human control, erroneous credit, and discriminatory outcomes in the development of design products. The proposed socio-technical framework defines AI automation as an aid tool that leverages human intuition in crowdsourced design applications. The framework will come up with an ethical and transparent framework that will be combined with Reciprocal Human-Machine Learning (RHML) and Polanyi Paradox, and Algorithm Aversion to provide a collaborative system between AI and humans. It is important to create a shielding system not only to defend creative freedom but also to secure intellectual properties and make people more confident in the work of AI-assisted functions. The system must incorporate AI features that can work in conjunction with human creative supervision and oversight. The impact of AI on human intuition in creative work should be analyzed in research, as it involves a complex interplay of ethical values, social responsibility, and creative benefits. The investigation of the gaps analysis allowed the authors to formulate a research question aimed at the investigation of the mechanisms of RHML functioning in cooperation with the Polanyi Paradox and Algorithm Aversion to come up with an effective system that will handle the management of AI automation and human intuition in crowdsourced design, thus protecting ethical cooperation, creative independence, and trust in the working process of the AI-assisted working process.

The authors developed a structured socio-technical framework that integrates Reciprocal Human-Machine Learning (RHML) with the Polanyi Paradox and Algorithm Aversion. AI applies RHML to establish a continuous learning connection with human designers, enabling creative changes in workflows (Te'eni et al., 2023). According to the paradox presented by Polanyi, the human capability of possessing implicit knowledge will continue to be beyond the capability of AI systems; therefore, designers are expected to monitor their design decisions (Polanyi, 1966). The necessity for users to comprehend AI systems is explained by Algorithm Aversion, as the lack of clarity in the system leads to mistrust and a lack of human-machine collaboration (Jussupow et al., 2020). The theoretical aspects of this framework suggest that AI systems should be utilized as a creative support system, rather than a system of independent decision-making. The original value of this concept paper lies in transforming the customary argument on AI automation and human creativity into an AI assistant system strategy. The suggested framework would help deploy AI in crowdsourced design by merging inclusive, ethical principles and human-centered design frameworks that safeguard creative freedom, human instinct, and authorial control. The study identifies the primary needs to be used in further experiments, enabling the authors to develop the basis for sustainable and fair artificial intelligence integration into creative companies.

Literature review

Understanding AI integration challenges and opportunities in creative processes demands evaluating past research about socio-technical systems, human-AI co-working, and algorithmic decision-making. This part of the critical review will examine reliable research regarding AI-driven crowdsourced design and its effects on human creativity.

Social-technical system in crowdsourced creative workflow

The emergence of Socio-Technical Systems (STS), in connection with technological advancements such as artificial intelligence (AI) and the engagement of various stakeholders in creative activities, has become significant in the setting of crowdsourced creative workflows in terms of current technological development. The literature on the issue has discussed the problem of interdependence between the social and the technical foundations of systems; therefore, they should consider developing a model that would enable a creative interface of persons who contribute to the systems. In matters regarding the socio-technical nature of Industry 4.0, the study by Roth and Farahmand analyzes the transition towards higher integrated digital solutions, something that is mainly relevant to small and medium enterprises (SMEs) and their eventual transition into greater integration. They present a notion of the significance of the sociotechnical aspects in the productivity growth and the possibility to conduct technological interventions in the form of well-thought-out solutions to the demands of always and constantly changing human workers in these systems (Roth and Farahmand, 2023). The realization is significant in a crowdsourced design context where various actors with varying capacities, interests, and expectations exist. Furthermore, Bos et al. go further to present another model that would aid in correlating individual goals of stakeholders and the goals of the whole society through Butterfly Framework. It refers to the importance of the socio-technical processes toward a more sustainable and more integrated society. This framework can inform the work of crowdsourced design to take into consideration the opinions of any stakeholder, and thus, creative creation would not only be useful in a specific sphere but would also influence other social goals (Bos et al., 2022).

In addition to the frameworks, the same evolutionary nature of the socio-technical systems presented by Moiseeva and Myatishkin also outlines the mutual necessity of such systems to involve social structure and technical structure. In their work, they also indicate a necessity to develop systems capable of adapting to the needs and behaviours of users, and it is of utmost importance in a creative environment where the flexibility of the partnerships is at the core of innovation and idea generation (Moiseeva and Myatishkin, 2021). Besides, the theory of socio-technical systems adopted by Lee et al. also helps to study the functioning of crowdsourced platforms on the example of the food delivery industry. Based on their findings, the outcome of crowdsourced workers in terms of job performance is enhanced with the implementation of strategies grounded on the socio-technical systems thinking. This is a critical perception of the crowdsourcing of creative activity, during which the involvement and satisfaction of community members can be critical to defining the quality and efficiency of the collaborative output (Lee et al., 2022). Finally, the ethical model offered by Bruxvoort and Keulen (2021) also contributes more to the debate since it also manages to include a socio-technical perspective in the evaluation of AI and algorithmic decision-making in organizations. This framework has been particularly applicable in the cases of crowdsourcing design, since it promotes ethical influence of technology in human collaboration and creativity; thereby ensuring that the systems designed and developed are not only effective, but also reasonable and responsible (Bruxvoort and Keulen, 2021). This combination of sources allows us to conclude that there is no doubt that a new socio-technical crowd-sourced system of the design processes is required, as it would help to align the complexity of humans relating to one another with the new technological advances. Such a total system would possibly produce an environment

whereby a greater level of so-called creative synergy could be attained that ultimately results in innovation and common multi-solving during design activity.

AI automation and human intuition in collaborative design

Automation of artificial intelligence (AI) and intuition of human beings in collaborative design is one of the crucial fields of research, especially since organizations are trying to promote the creation of an environment where both technological and the creativity of people are used to the maximum. The necessity to develop a new socio-technical framework that would enable the collaboration between AI automation and human intuition to foster a more synergistic approach to creativity in crowdsourced design is discussed in this literature review. Recent research demonstrates that it is crucial to study the affordances and constraints of human-AI collaborations. The structure of interaction patterns between humans and AI is crucial to the maximum productivity and innovation in collaborative design settings (Liang et al., 2024). Authors explain that it is possible to divide these patterns into automation, which makes doing certain things simpler with the help of AI, and augmentation, which helps people to be more capable with the help of AI. Such a difference is central to how organizations can make use of AI technologies in a way that makes them supplement human creativity instead of overtaking it. Furthermore, the current rapid development of AI technologies, as explained by Chen et al., demonstrates the possibility of AI to handle more complex tasks, leaving human designers to focus on the more innovative and emotionally sensitive aspects of the design work. AI systems help creative professionals get rid of lower-value activities, as they allow them to concentrate on critical thinking and emotional intelligence, thereby improving the overall design process. Such a split between the roles of AI, which is to enhance human input rather than replace it with automation, indicates the necessity of models that support integrated solutions, underscoring the mutuality of the relationships between technological and human contributions to the creative process.

Also, Roth and Farahmand (2023) point out the importance of socio-technical relations that are crucial in terms of Industry 4.0, implying that the incorporation of technological aspects into the socio-economic context can significantly affect the design approach in small and medium enterprises (SMEs). This implies a more inclusive structure that goes beyond the limits of the individual and involves organizational systems, and thus encourages collaborative work involving both AI and human actors. The systematic approaches to the evaluation of socio-technical systems presented in their work can be used as an example in the creation of the integrated frameworks that can improve collaborative design. The need to have optimized frameworks that would include collaborative decision-making mechanisms is also justified by studies conducted in a healthcare environment, where Ahsen et al. discuss how collaborative decision-making strategies involving humans and machines could result in better outcomes (Ahsen et al., 2023). They suggest that framework development for how humans can best collaborate with AI can be informed by understanding the circumstances in which this collaboration is most effective in improving human decision-making in complex, creative design tasks.

Lastly, the study by Zong et al. (2023) on crowd-AI collaboration to reduce demographic bias in educational predictions gives an excellent example of how such frameworks could be implemented in crowdsourced settings. The fact that they have developed their debiasing mechanism proves that a team effort, which includes the

human component and AI, can provide more accurate and fairer results. This opens the door to the same use in design disciplines, where crowd dynamics knowledge and AI potential can be used to improve both creative and pragmatic outputs. Finally, an integrated reciprocal human-AI socio-technical system should be created to promote the creative synergy in crowdsourced design. With the help of knowledge and ideas from various studies that examine human-AI cooperation, organizational processes, and collaboration, it is possible to state that a multifaceted approach that values both automation and human wisdom will play a key role in future design innovation.

Ethical consideration in AI driven design systems

The emergence of artificial intelligence (AI) in design systems is a complex set of ethical and technological advancements. As the sphere of design practice increasingly relies on AI systems, it is necessary to know about their moral implications to ensure that the technologies will reinforce societal values rather than ruin them. The literature review includes a summary of the recent works that mention the need to have a new ethical code that is specially tailored to the AI-driven design systems, particularly within the context of crowdsourced design. The main aspects of ethical AI development include the inclusion of the opinions of other stakeholders. According to previous study, stakeholders, including developers and potential users, can significantly enhance the ethical perspective of emerging technologies by involving them in the early stages of AI technological development. Early engagement may provide insight into morally relevant aspects of design choices and their broader societal consequences and provide a foundation upon which ethical evaluation of AI systems can be made. The qualitative knowledge that is gained because of such stakeholder involvement can assist the developers to transcend the potential ethical dilemma, which can improve the whole design of AI-based solutions.

In the case of crowdsourcing, the ethical dimension needs to be examined in a different direction, since the interconnections between technology and human agents are complex. Ahn et al. suggest a more people-centered redesign of crowdsourcing activities, which not only recognizes the need for ethical frameworks but also promotes the learning and growth aspects of participant engagement. This kind of worldview regards people as active participants in the design process, rather than data processors, and introduces a new vision that considers the experiences of participants, thus enabling the establishment of a more ethical environment in crowdsourced design projects. In addition to this, the ethical issues of AI-based platforms ought to be addressed with ad hoc development of design and business models, which are inclined to ignore ethical principles. Familoni provides an explanation as to why an organized ethical system is needed to circumvent the problems that AI presents to various industries, such as healthcare entrepreneurship. He stresses that the subject of ethics needs to be constantly discussed since there must be a clear structure to be able to develop and implement AI systems in any discipline in a responsible manner, including design. The practice concurs with the claim that existing practices require change when it comes to handling crowdsourced initiatives, and a more systematic framework can be applied to provide practitioners with information on how to avoid the ethical pitfalls experienced during the design phase.

The solution to the vital problems of information technology is also discussed by Olorunfemi et al based on the elaboration of an ethical framework of AI. They present a complex conceptual framework that would assist in achieving the ethical development

of AI, grounded in general values and the legal context (Olorunfemi et al., 2024). It is not merely a blueprint for practitioners in the IT field, but it also has implications for design systems as they go on to embrace AI technologies. To sum up, there is a feeling of urgency in the context of the existing problem of a new integrated reciprocal human-AI socio-technical framework with consideration of ethical issues in the design systems powered by AI. By incorporating the perspectives of the stakeholders, reworking the workflows to make them participant-centered, and establishing robust ethical systems, AI will be able to enhance creative synergy in crowdsourced design without having to intrude on ethical standards. These structures must always be negotiated and altered in order to meet the dynamic world of AI and design.

Crowdsourced design and generative creativity

The study of crowdsourced design and generative creativity is becoming a trend in the present-day arena of innovation, which confirms the need for an all-embracing human-AI socio-technical framework. Crowdsourcing, which refers to a practice of getting input or services from many people and possibly through the Internet, has changed the paradigm of product designing and developing. Not only does it utilize the intelligence of the combined participants, but it also combines it with the generative AI technologies, contributing to the greater results regarding creativity. The basic building blocks of crowdsourcing projects have to be investigated to comprehend this development. Karachiwalla and Pinkow posit that value capture and strategic business models are key elements that should be considered to maximize the effect of crowdsourcing activities on innovation (Karachiwalla and Pinkow, 2021). According to the authors, the crowdsourcing competitions can be well-designed to achieve substantial increases in the volume of creativity and efficiency in innovation. Furthermore, the form of the design process is also paramount since it determines how the input of various people in a crowd is added and integrated into clear solutions. An important role in this respect is played by generative creativity, which is strengthened by AI systems. According to Cross and Ramsey, the necessity of interdisciplinary cooperation in the creation of meaningful human-AI interactions is a must, and creating a machine that would be able to socialize and create with humans is only possible with the expertise of cognitive sciences (Cross and Ramsey, 2021). Such an insight can be attributed to the idea of integrated frameworks in marketing analytics, on the idea of how combining data insights provided by AI-based technologies and human creativity can improve personalization and customer engagement rates by considerable margins. These human-machine synergies can be used in directing the design activities of crowdsourced innovation.

Nonetheless, to achieve a real implementation of human creativity and AI potential, the functionality of the crowdsourcing process should be made to work in a systematic manner. The study of Song et al. on the modeling of crowdsourcing design processes finds an opportunity in the aspect of the execution of complex product design, where generative AI may be revolutionary. They claim that to enhance possible creative synergy in crowdsourcing, frameworks describing the working dynamics of interactions between human users and AI agents should be used. Also, Lawrence et al. outline how shared control in AI orchestration tools can transform the creative process in the learning context. Their understandings indicate that systems enabling a hybrid-type human-AI collaboration with different degrees of autonomy can cultivate a greater creative synergy within the crowdsourcing model, welcoming a multiplicity of

contributions that disrupt a conventional design process (Lawrence et al., 2023). Conclusively, generative creativity and crowdsourced design require a new socio-technical architecture that could not only encompass the essential aspects of crowdsourcing and design but also efficiently mesh the ability of humans and AI. This framework should enable constant feedback, flexibility, and collective imagination, based on solid principles from cognitive sciences and practical experiences from various industries.

Theoretical references

Previous studies about AI in design workflows fail to establish a transparent system that integrates machine automation and human instinct. The authors integrate a socio-technical framework that unites Reciprocal Human-Machine Learning (RHML) with Polanyi's Paradox and Algorithm as theoretical references to address this gap (*Figure 1*).

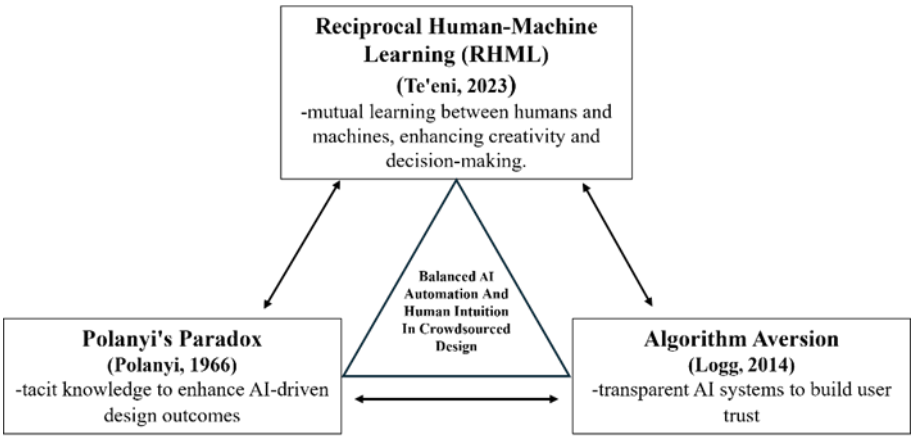

Figure 1. *Integrated reciprocal human-AI socio-technical theoretical framework.*

Reciprocal Human-Machine Learning (RHML)

The crowdsourced design requires effective interactions between artificial intelligence automation and human intuition through the complete understanding of RHML and Polanyi Paradox and Algorithm Aversion. The three theories provide different perspectives regarding the interaction of humans and AI, and they contribute to the creation of systems that combine the high-efficiency and expertise of AI with the skills of humans. RHML represents an academic framework that enables human involvement with AI devices through reciprocal education mechanisms (Te'eni et al., 2023). Systems linked through RHML maintain an ongoing information exchange to enhance their learning abilities and develop new capabilities. Crowdsourced design environments gain their highest value from adaptive learning because they handle complex tasks that thrive under this approach. The RHML system allows AI algorithm updates through human feedback processing about message classification operations. AI systems produce vital insights that experts use to improve accuracy and efficiency in their work output. The dynamic nature of crowdsourced design grows stronger through RHML because it establishes successful human-computer collaboration. Machine systems analyze extensive data volumes to discover patterns by executing them for quick repetition-based processing. Human designers feed machines with creative thinking abilities, contextual understanding, and defined judgment, which machine

systems lack. AI tools acquire data from human interaction to develop through principles humans have designed. The interaction between humans and machines produces higher-quality design outputs that deliver solutions that fulfill user requirements properly.

Designers must deploy algorithm aversion solutions at the end of their AI tool implementation process to maintain trust in their work. Users demonstrate algorithm avoidance behavior because they encounter AI decisions that are confusing, untrustworthy, and avoidable when these decisions differ from their expectations of human judgment following errors. Users stop using AI tools because their value decreases due to this behavior. Platforms that design solutions must integrate transparency elements that combine explainable AI functions with active user control capabilities. Users' acceptance of AI systems increases when developers understand AI reasoning and designers retain AI output control through refinement capabilities and trust-boosting features. AI systems that designers can work with to improve their expertise will be regarded as valuable tools rather than controlling mechanisms. The advancement of technology at a controlled pace alongside human ethical principles results in more efficient and innovative designs that allow the independent creation of solutions that fulfill user needs while maintaining ethical standards.

Polanyi's paradox

In his philosophical work, Polanyi (1966) has shown that tacit knowledge can be retained by humans through an inarticulate and profound knowledge of skills that are difficult to articulate. Although it was published in 1966, the Polanyi Paradox remains true since it explains why AI will never be able to replicate human intuition. Creativity is likely to be based on tacit knowledge of things you know but cannot explain in a short time. Therefore, AI can hardly understand AI automation, and it faces one of the most technical restrictions since machines are able to work with data only when they are defined in advance. The machines are unable to imitate human intuition, emotional intelligence, or implicit reasoning abilities. The design that is crowdsourced needs imagination and personal opinions as well as original thinking, which is a strong indicator of the Polanyi Paradox in action. The human contributors use their professional expertise, cultural intelligence, and aesthetic capability in making design choices that transcend the systematized knowledge by making decisions. The primary issue of AI implementation concerns recognizing the cognitive boundaries and creating automation systems that improve human intuition rather than replace it.

The best way to apply the technology of AI to design operations would be to make it act as a supplement to human design potential. AI conducts an intensive analysis of the databases as it runs through the usual steps of prediction modeling, rapid model development, and continuous evaluation testing. This will allow designers to concentrate on intricate mental issues, create new ideas, and make smart business decisions. This joint system is advantageous for designing functions, and it generates genuine results that show cultural awareness, emotional traits, and AI work capacity and processing speed. The AI tools should have data absorption capabilities that utilize information on human reviews to customize functions on the basis of the choices made by the user and judgments by professional experts. The idea of human-AI collaboration implemented via design platforms can assist users in overcoming obstacles created by the Polanyi Paradox in order to attain full automation of creative assistance. This will ensure that AI is used as a human capitalization tool since the new human creative

inputs will not only enhance the crowd-sourced design options but also preserve core human capabilities in comprehension, artistic skills, and contextual decision-making.

Algorithm aversion

After witnessing mistakes, societies are cautious about algorithmic choices and algorithm aversion (Logg et al., 2014). The effect leads to challenges applying AI systems in numerous fields, such as crowdsourced design areas. Human choices over algorithmic choices are what individuals want, despite algorithms being effective in certain operations based on witnessed errors. As users exhibit such negative responses, they restrict their use of AI systems by facilitating potentially flawed human judgments. Creating expectation-congruent and transparent AI systems is based on algorithm aversion, as this helps build trust and effective human-AI interaction. Applying user trust-fostering techniques and acceptance strategies to artificial intelligence applications is a way of evading algorithm aversion in crowdsourced design. Transparency in AI decision-making must be boosted as a practical approach towards progress. The inclusion of explanations of algorithms by designers helps end-users better comprehend AI functions, thus gaining appreciation and trust in working with these systems. Users involved in system design and improvement of AI tools generate more confidence as they know they are seeing their input instantaneously, so they can make improvements in systems. Informing the user about the pros and cons of AI reduces unrealistically high expectations and the level of resistance towards AI systems. Crowdsourced design sites taking a proactive approach to these issues will enhance the process of collaboration between humans and AI and make it more efficient.

The successful implementation of AI automation in crowdsourced design requires complete knowledge of Reciprocal Human-Machine Learning (RHML) and Polanyi's Paradox and Algorithm Aversion so designers can establish a balanced and effective design system. RHML facilitates ongoing information sharing between human designers and AI systems, progressively allowing both parties to gain knowledge from each other. The double learning process allows AI algorithms to be reinforced with human input and allows human creators to tap into AI data to reinforce creativity and decision-making. The absence of data interaction between human designers and AI would have two negative impacts: human designers struggle to manage significant amounts of data efficiently. At the same time, AI systems have become inflexible when it comes to designing trend updates. RHML boasts an adaptive system of adaptation, whereby AI facilitates design decisions rather than dictating them, thereby creating an adaptive collaborative process that can solve creative problems. Understanding Polanyi's paradox enables us to recognize the boundaries of AI when it replaces human intuition and tacit knowledge, as these elements prove challenging to transform into formal or quantifiable data.

Design activities involving crowdsourced approaches depend on human creativity in delivering emotional and cultural aspects and aesthetic understanding features beyond AI computational ability. AI demonstrates a superior ability to detect patterns with its automatic operations and solution optimization functions, but cannot imitate human experience-based knowledge, design instinct, and situational perception. Understanding Polanyi's Paradox helps keep AI within its augmentation role compared to human intellectual capabilities. Preserving human intuition and strategic management allows crowdsourced design platforms to maintain authentic outputs appropriate to their context and culturally consistent while using artificial intelligence. This design

approach enables automation to bring as much value as possible without compromising the rich human-designed character.

Conceptual framework

The presented conceptual framework depicts an advanced socio-technical interaction between Reciprocal Human-Machine Learning (RHML) and the ensuing concept of Creative Synergy in crowdsourced design. RHML is the Independent Variable (IV), which is the main driver of the framework (*Figure 2*). It has four key sub-components, which are Bidirectional Knowledge Exchange, AI Feedback Integration, Human Feedback Quality, and System Adaptability. This variable represents a dynamic, ongoing process in which humans and AI systems share knowledge, enabling both to learn, adapt, and perform more effectively together. Human players provide necessary domain-specific information and explanations, while AI responds and adapts to them, creating a dynamic and evolving learning environment. These mutual interactions stimulate the changes in algorithms and improve the potential of human creativity and AI efficiency.

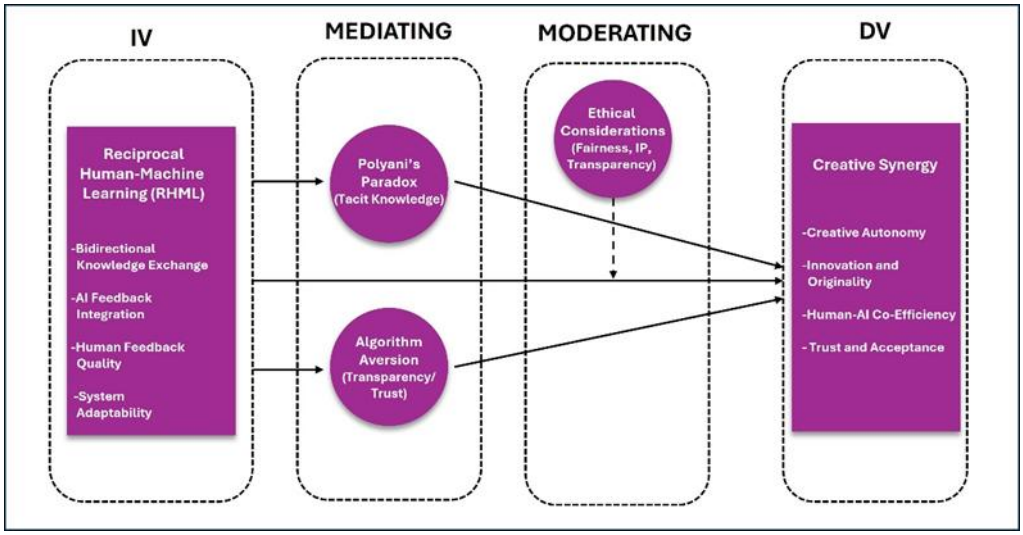

Figure 2. *Reciprocal human-AI socio-technical framework.*

The key to this framework is two Mediating Variables: Polanyi Paradox (Tacit Knowledge) and Algorithm Aversion (Transparency and Trust). The Paradox of Polanyi is an acceptance of the fact that there are limitations to what AI can do in order to emulate human tacit knowledge, including intuition, emotional intelligence, cultural context, and aesthetic knowledge. Since the intangible human qualities cannot be entirely embodied by AI, the human designers will not lose their irreplaceable role in the creative process. At the same time, Algorithm Aversion highlights the importance of transparency and explainability of the AI processes. People tend to be reluctant or even refuse to accept AI-assisted decisions when algorithms are not transparent, not understandable, or seem unreliable. Therefore, the framework contributes to the increase of trust between human users by making AI processes transparent and comprehensible, which leads to a higher readiness to cooperate and accept the input of AI in creative work. In addition, Ethical Considerations is considered as a Moderating Variable, which has a major regulatory role in this socio-technical interaction. Ethical

Considerations- such as fairness in practice, Intellectual property (IP) protection, and transparency of operations are necessary in establishing a balance and integrity in human-AI interactions. The interactions within this framework, when well moderated by strong ethical principles, result in the Dependent Variable, Creative Synergy, which is a holistic result of Creative Autonomy, Innovation and Originality, Human-AI Co-efficiency, and Trust and Acceptance. Creative Synergy means an optimized collaborative space where AI complements and does not substitute human creativity to enable new, innovative, and ethically acceptable results. Such a combined strategy will make technological progress and human creative values, autonomy, and societal ethics compatible, and lead to sustainable and meaningful partnerships in crowdsourced creative environments.

Framework justification

The suggested Integrated Reciprocal Human-AI Socio-Technical Framework gives a unique and strong answer to the constraints noticed in current frameworks of AI-assisted crowdsourced design. The purely computational efficiency or algorithmic management approaches are traditional approaches, which usually do not pay much attention to the human aspects of the creative processes. Amazon Mechanical Turk and OpenIDEO are examples of platforms with mostly automation-based structures that focus more on the efficiency of the task distribution than the creativity of the work, human intuition, and ethical aspects. Such an approach is likely to cause inflexible work processes and the lack of individual input into the work, often leading to impersonal, monotonous results and less human creative freedom. Conversely, the suggested framework is properly designed to include Reciprocal Human-Machine Learning (RHML) in an active way, enabling constant and reciprocal adjustment between human designers and AI, which upholds creative freedom and encourages innovation. In such a way, the approach shifts the focus of the traditional productivity-centered models towards the synergy-centered model that focuses on the human interaction with the AI.

Besides, the mediating functions of tacit knowledge and algorithm aversion are mostly not accounted for by the existing frameworks. Even known theories like the Polanyi Paradox are rarely integrated into the current socio-technical structures in a systematic way, which means that there is insufficient knowledge of the inherent limits of AI in terms of creativity and intuitive decision-making. In the same way, Algorithm Aversion, which focuses on transparency and user confidence in AI, is commonly overlooked in the modern automation-intensive systems and results in a high rate of resistance, mistrust, and diminished performance of human-AI interaction. This new framework solves these fatal omissions by making Polanyi Paradox and Algorithm Aversion an explicit part of the framework, providing transparency to AI, and making it clear that technology should not be seen as a replacement, but as an aid. It, therefore, encourages user trust, makes it more acceptable, and preserves human intuitive decision-making abilities, which are vital in the processes that involve creativity.

Besides, ethical aspects are often not given the needed attention in the available frameworks, particularly in AI-based crowdsourcing systems where issues of fairness, intellectual property, and transparency are mostly sidelined to favor efficiency. Such frameworks as Value-Sensitive Design (VSD) and Human-Centered Artificial Intelligence (HCAI) usually do not put ethical considerations at the centre of balancing between human intuition and the capabilities of artificial intelligence. The suggested Integrated Reciprocal Human-AI Socio-Technical Framework is a highly valuable

contribution to the current models as it incorporates the issue of ethics in the form of a moderating factor that alters the correlation between RHML and the creative output. The inclusion of fairness, intellectual property protection, and transparency of operations as moderating variables clearly puts the ethical responsibility in the foreground of this approach. It is therefore fair to say that it guarantees fair contribution, safeguards individual input, and promotes openness in the design processes. Finally, such integration provides sustainable, ethical, and synergistic cooperation of humans with AI, which makes such a framework superior to other traditional frameworks because it covers all human, ethical, and intuitive aspects that have been overlooked in the context of the AI-driven design environment.

The application of Artificial Intelligence (AI) on the crowdsourced design platforms has the potential to improve the performance of operations and their scale, but it also creates serious socio-technical issues, especially when it comes to maintaining human creativity, autonomy in decision-making, and ethical considerations. Socio-technical systems (STS) have in their nature the focus on putting together technological mechanisms and social factors to make sure that the improvement of technology does not decrease human abilities. The existing AI-based platforms, such as Amazon Mechanical Turk and OpenIDEO, are generally oriented towards computational effectiveness and automation at the expense of human creative agency, resulting in inflexible workflows and algorithmically uniform results that inhibit the original creative solutions (Irani, 2015; Kittur et al., 2013). Such platforms show that a heavy dependence on AI may unintentionally result in algorithm-based limits and erode the freedom, creativity, and instinct of human employees (Rosenblat and Stark, 2016). To ease these negative implications, the given Reciprocal Human-AI Socio-Technical Framework directly focuses on filling these gaps by introducing Reciprocal Human-Machine Learning (RHML). The RHML focuses more on the ongoing knowledge flow in the two-way direction, where AI systems are informed by human inputs and vice versa, where the AI systems adapt and improve human tasks through feedback and flexibility in real-time. This kind of two-way interaction will make sure that the role of the AI is not substitutive, but supportive (as the AI will be dynamic in adapting to the human creativity). Thus, it will maintain and increase the value of human intuition and innovation. The interactive learning loop enables human designers to make the most of the computational capabilities of AI without undermining their own creativity by creating the conditions in which human and machine work in synergy to develop their individual strengths (Te'eni et al., 2023).

This framework is also distinguished by the inclusion of Polanyi Paradox and Algorithm Aversion as the significant mediating variables. Polanyi's Paradox makes obvious the inherent weaknesses of AI in imitating the human tacit knowledge, the knowledge that can be recognized intuitively but is hard to articulate, like emotional intelligence, cultural contexts, and aesthetic judgment. It is important to be aware of such limitations to sustain human decision-making functions in the creative processes. At the same time, Algorithm Aversion puts emphasis on the transparency and trust in AI. It underlines that ambiguous or black-box algorithmic procedures tend to cause the rejection of users and lower levels of acceptance of AI-made decisions. The proposed framework is also directly addressing the issue of algorithm aversion by systematically integrating the concepts of transparency, explainability, and clarity into the workings of AI, therefore making AI technologies more understandable and trustworthy to the users, consequently increasing their acceptance and cooperation (Jussupow et al., 2020). The

moderating factors of this socio-technical system are ethical, including fairness, intellectual property protection, and transparency of operations. These moral aspects cover the most important matters that are usually overlooked by the current systems, and human input will be rewarded and appreciated. The framework keeps human participants and technological agents on par by protecting intellectual property and acting in a just manner when it comes to rewarding contributions. Transparency in operations will make all stakeholders clearly aware of how much AI is involved in the design processes, and it will keep the collaboration integrity and trustworthy.

Finally, the Reciprocal Human-AI Socio-Technical Framework is a strategic way of addressing major gaps that exist in the current frameworks by specifically incorporating human creative intuition to adaptive AI processes, clearly demarcating the AI boundaries through the Polanyi Paradox, and improving user trust through transparent algorithmic practices. This framework can guarantee fair, transparent, and meaningful collaboration between humans and AI because it prioritises ethical concerns, which will eventually lead to creative synergy. Such a strategy will not only help to increase the efficiency of operations but also provide strong safeguarding and empowerment of human creativity, innovation, and independence in crowdsourced design systems and create a solid ground of sustainable and ethically acceptable AI integration.

Conclusion

The Reciprocal Human-AI Socio-Technical Framework is a highly significant step in resolving the paradox of AI efficiency and creativity in the human-centered design using crowdsourcing. The framework does not compromise the individuality of human intuition, emotion, and cultural context that constitute authentic creativity by positioning AI as a collaborator rather than a substitute. The model enables a reciprocal co-learning between humans and AI systems to occur in the form of the Reciprocal Human-Machine Learning (RHML). This way, AI systems can absorb the knowledge of human expertise and, at the same time, expand human capabilities through adaptation and computing power in real-time. This never-ending dialogue helps create a creative environment that behaves in a manner that adds value to both designers without displacing the important role of human choice and creativity. In addition to that, the intermediary aspects of the Paradox of Polanyi emphasize that the tacit knowledge can barely be programmed or replaced, which further proves the notion that AI ought to remain nothing more than a tool, but not a decision-maker. This is what makes the framework unique among the existing design paradigms of AI, since the concept of ethical moderation is explicitly included in the framework. The model also ensures that performance is achieved both technically and ethically through the instilling of the notions of fairness, intellectual property rights, and transparency in its operating system. This is quite significant in the development of trust, making them be accepted in the long term, and allowing people to participate in the AI-assisted design process in a non-exclusive way. The issue of algorithm aversion, typically overlooked in the existing systems, is addressed by explainable AI and open workflows; they minimize the fear of using the system or the unwillingness to use the algorithm. Basically, such a socio-technical approach is necessary and timely enough to offer an escape route out of the existing scenario where human creativity and autonomy are at stake, innovation is promoted, and human dignity is guaranteed in the rapidly evolving reality of AI-based design.

Acknowledgement

The author want to thank all co-authors for their valuable time, knowledge, and cooperation, which made this work possible.

Conflict of interest

The authors confirm that no conflict of interest exists with any parties involved in this paper.

REFERENCES

[1] Ahsen, M.E., Ayvaci, M.U.S., Mookerjee, R. (2023): When Machines Will Take Over? Algorithms for Human–Machine Collaborative Decision Making in Healthcare. – Proceedings of the 56th Annual Hawaii International Conference on System Sciences (HICSS-56), IEEE Computer Society 8p.

[2] Baxter, G., Sommerville, I. (2011): Socio-technical systems: From design methods to systems engineering. – Interacting with Computers 23(1): 4-17.

[3] Bos, H.L., de Haas, W., Jongschaap, R.E.E. (2022): The Butterfly Framework for the assessment of transitions towards a circular and climate-neutral society. – Sustainability 14(3): 1516-1528.

[4] Brabham, D.C. (2008): Crowdsourcing as a model for problem solving: An introduction and cases. – Convergence 14(1): 75-90.

[5] Bruxvoort, X., Keulen, M. (2021): Framework for assessing ethical aspects of algorithms and their encompassing socio-technical system. – Applied Sciences 11(23): 29p.

[6] Crawford, K. (2021): Atlas of AI: Power, politics, and the planetary costs of artificial intelligence. – Yale University Press, New Haven 336p.

[7] Cross, E., Ramsey, R. (2021): Mind meets machine: Towards a cognitive science of human–machine interaction. – Trends in Cognitive Sciences 25(3): 200-212.

[8] Irani, L. (2015): The cultural work of microwork. – New Media & Society 17(5): 720-739.

[9] Jussupow, E., Benbasat, I., Heinzl, A. (2020): Why are we averse towards algorithms? A comprehensive literature review on algorithm aversion. – European Conference on Information Systems (ECIS 2020) 17p.

[10] Karachiwalla, R., Pinkow, F. (2021): Understanding crowdsourcing projects: Key design elements for creativity and innovation. – Creativity and Innovation Management 30(4): 678-691.

[11] Kittur, A., Nickerson, J.V., Bernstein, M., Gerber, E., Shaw, A., Zimmerman, J., Horton, J.J. (2013): The future of crowd work. – Proceedings of the ACM Conference on Computer-Supported Cooperative Work 2013 17p.

[12] Lawrence, L., Echeverria, V., Yang, K., Aleven, V., Rummel, N. (2023): Teachers' conceptualisation of shared control with AI co-orchestration tools: A multiyear design process. – British Journal of Educational Technology 54(4): 1123-1142.

[13] Lee, S., Chang, H.S., Cho, M. (2022): Applying socio-technical systems theory to crowdsourcing food delivery platforms: A worker perspective. – International Journal of Contemporary Hospitality Management 34(3): 1125-1142.

[14] Liang, Q., Gou, J., Wang, Z., Dabić, M. (2024): Affordances and Constraints of Automation and Augmentation: Lessons Learned From Development of a Human-AI Collaboration Business Simulation Platform. – Journal of Global Information Management (JGIM) 32(1): 1-27.

[15] Logg, J.M., Minson, J.A., Moore, D.A. (2014): Algorithm appreciation: People prefer algorithmic to human judgment. – Journal of Experimental Psychology: General 143(1): 1-13.
[16] Moiseeva, T., Myatishkin, Y. (2021): Innovative development of socio-technical systems. – SHS Web of Conferences 101: 6p.
[17] Olorunfemi, O.L., Amoo, O.O., Atadoga, A., Fayayola, O.A., Abrahams, T.O., Shoetan, P.O. (2024): Towards a conceptual framework for ethical AI development in IT systems. – Computer Science & IT Research Journal 5(3): 616-627.
[18] Polanyi, M. (1966): The tacit dimension. – Doubleday, New York 108p.
[19] Rosenblat, A., Stark, L. (2016): Algorithmic labor and information asymmetries: A case study of Uber drivers. – International Journal of Communication 10: 3758-3784.
[20] Roth, K., Farahmand, K. (2023): A socio-technical study of industry 4.0 and SMEs: recent insights from the upper midwest. – Sustainability 15(16): 19p.
[21] Shneiderman, B. (2020): Human-Centered AI: Reliable, safe, trustworthy. – International Journal of Human–Computer Interaction 36(6): 495-504.
[22] Starbird, K. (2019): Disinformation's spread: Crowds, algorithms, and AI. – Nature 571(7766): 449-450.
[23] Te'eni, D., Schwartz, D.G., Lichtenstein, Y. (2023): Reciprocal Human–Machine Learning: Theory and applications. – Journal of the Association for Information Systems 24(2): 123-145.
[24] Zong, R., Zhang, Y., Stinar, F., Shang, L., Zeng, H., Bosch, N., Wang, D. (2023): A Crowd–AI collaborative approach to reduce demographic bias in education. – Proceedings of the AAAI Conference on Human Computation and Crowdsourcing 11(1): 198-210.