AI-informed Collective Intelligence for Inclusive Research Capacity in Global Education: A UK-Pakistan Empirical Framework

1st Preeti Patel
School of Computing and Digitl Media
London Metropolitan University UK
p.patel@londonmet.ac.uk

2nd Bilal Hassan
School of Computing and Digital Media
London Metropolitan University UK
b.hassan@londonmet.ac.uk

3rd Amanullah Yasin
Dept. of Computer Science,
Bahria University
Islamabad
Pakistan
amanyasin11@bahria.ed.pk

4th M Farooq Wasiq
Perspective Policy Research Institute Islamabad
Pakistan
dg@pprii.org

5th Malika Rani
Dept. of Physics.
The Women University
Multan
Pakistan
dr.malikarani@wum.edu.pk

6th Shanawer Niaz
Dept. of Physics
Thal University
Bhakkar
Pakistan
shanawer.niaz@tu.edu.pk

7th Khadija Naveed
Dept. of Artificial IntelligenceUniversity of Mgt. and Tech. Lahore
Pakistan
khadija.naveed@umt.ed.pk

***Abstract*—With increasing priorities in engineering education like sustainability, equity, and ethical accountability, scalable methods are needed to support an inclusive research collaboration across transnational partnerships. This paper introduces the TNS–AI-CI pedagogical framework, developed through the UK–Pakistan Transnational Synergy (TNS) Project, to examine how AI can support equitable and accountable co-supervision and collaborative academic writing in higher education. Using a convergent mixed-method design (platform analytics, surveys, reflections, and interviews) across five partner universities, we observed statistically significant improvements in transparency of authorship, supervisor accountability, and women's confidence as academic leaders, including an average supervision feedback time of under five days and post-workshop self-efficacy scores of ≥4.7/5. This contribution has been validated, and a transferable framework is proposed for AI-informed collective intelligence which supports highly equitable and ethically informed knowledge production in STEM.**

Keywords—— Research capacity building; Collective intelligence; Virtual supervision; Artificial intelligence; Gender equity; Transnational higher education.

I. INTRODUCTION

With globalization and technological advancements, new pressures have emerged on higher education to meet the demand for equitable and sustainable ways of teaching, learning, and providing access to education. AI has rapidly transitioned from being largely used for teaching, researching, and supervising to becoming an integrated aspect of the entire process. Therefore, AI serves as an opportunity for collaborative co-creation of knowledge and for improving transparency, power, and fairness in education. In the interest of this study, AI-informed collective intelligence (AI-CI) represents the human relationship with AI technologies that enables the co-creation of shared knowledge and learning. AI has the ability to expand access to education [2] and also develop the capacity for inclusive and adaptive leadership within higher education [3]. In addition, the recent research on AI-CI indicates that while AI has been predominantly used for individual student support, it is yet to reach its full potential in developing CI (collective intelligence) as groups of individuals work with machines together to solve complex problems [4]. Transnational engineering education collaborations between institutions located in the Global North and those within the Global South intensify the existing disparity between these partnerships. Institutions located within the Global North typically face fewer (or lower-level) obstacles regarding their institutional capacity compared to institutions located within the Global South ("lessons on capacity," "lessons on gender and representation") and have a more extensive digital infrastructure than their counterparts located within the Global South. It has been documented that the varying types of AI governance have led to greater differentiation between institutional digital capabilities than previously existed [5], and the demographic diversity of participants corresponds to the amount and frequency of generative AI tool utilization within a particular institution, resulting in differing levels of participation across demographic backgrounds [6].

In view the of above, transnational education (TNE) brings forward not only challenges but also chances for more equitable and distributed knowledge production. The UK-Pakistan Transnational Synergy (TNS) Project funded by the British Council took shape under this aspirational vision when it examined how feasible AI-informed interventions could improve transparency of authorship, collaboration in research, and empower women in the academy. The project responded to three issues identified in the British Council's *Transnational*

Education Report published in 2022 [7], such as declining levels of joint co-authorship between scholars in the UK and scholars in Pakistan; limited access to remote supervision for PhD studies; and gender disparity in women reaching leadership positions in engineering.

TNS was set up to address these three mutually reinforcing pillars:

a. Collaborative Co-authorship, seeking to broaden joint publications and co-research;
b. Remote PhD Access, which is meant to provide distance supervision and mentoring for faculty in Pakistan; and
c. Women's Empowerment and Leadership, which targets agency and engagement of female researchers by way of a leadership and digital mentoring program.

This three-pillar design aligns with existing research demonstrating that hybrid training and supervision models can expand mentoring capacity [8] and that AI-based feedback systems promote greater equity in doctoral supervision [9]. Ensuring the fair and ethical use of such technologies, however, depends on interculturally responsive leadership [10].

Using these foundations as a guide, this paper presents the TNS–AI-CI pedagogical framework, a four-dimensional model that conceptualises AI-informed collective intelligence (AI-CI) as a cyclical learning ecology. The framework was developed by the authors through the UK–Pakistan Transnational Synergy (TNS) Project and draws on systems theory [11], collective intelligence research [12], [13], and experiential and transformative learning [14], [15]. It positions AI as an enabling layer that augments relational collaboration (rather than replacing human agents) and supports transparent, inclusive research practices through analytics and feedback that participants interpret. In this study, AI-informed collective intelligence refers to collaborative processes in which algorithmic systems provide analytic and organisational insights that inform—without determining—human decision-making. The TNS–AI-CI framework comprises four dimensions: (1) Engagement and Knowledge Co-construction, (2) Dialogue and Collective Understanding, (3) Application and Collaborative Production, and (4) Reflection and Transformative Learning. In the sections that follow, the framework structures the study design, data collection, and analysis across three project pillars: collaborative academic writing, virtual supervision, and women's leadership development.

II. Related Work

Research on artificial intelligence in education (AIED) has grown rapidly, as researchers have begun to investigate ways in which AI systems impact teaching, learning and research.
Hwang et al. [16] surveyed the history of the field and requested more empirical research regarding the potential benefits of using human-centered AIs to facilitate collaborative learning and academic authorship. In the same manner, Chen et al. [17] indicated that there were several large discrepancies between different methodologies employed in AI and education, and that many studies failed to sufficiently address how AIs could impact academic collaborations. Bhutoria [18] compared the implementation of personalised learning across national contexts and found that equity and cost issues remain unresolved. Crompton and Burke [19] confirmed the exponential growth of AI research in higher education but observed wide heterogeneity in quality and assessment methods. Together, these studies demonstrate rapid progress but also fragmentation in how AI is applied to collaborative and research-oriented academic practices.

Ethical and Equity Dimensions of AI

Recent research has debated the ethics and equity implications of AI and higher education. Review studies have shown that while optimistic about the prospects of AI, debates to date have not sufficiently considered the broader social impact of AI and pedagogical possibilities. For example, Bearman et al. [20] find that university discourse obfuscates these issues for pedagogy and governance. Issues regarding academic integrity have surfaced as Bin-Nashwan et al. [21] and Currie [22] identify generative AI risks as plagiarism, ghost writing, and fabricating content that raises academic integrity arguments. Deng et al. [23] find through meta-analysis of studies of AI assistants, that while large-language-model assistants support positive educational outcomes, they can also reinforce biases and transparency, depending on the quality of design. Likewise, Fu and Weng [24] argue, ongoing ethical dilemmas, or more specifically the ethical dilemmas of privacy, inequality, and transparency, may complicate cross-cultural situations.

Gender, Leadership, and Human Factors in Academia

Equity in the use of AI tools is also related to gender and leadership practices in the context of higher education. Research reveals that equitable technology use is based on not only how the technology is designed but also the culture within institutions and the specific leadership. For example, Beatty and Guthrie [10] stressed culturally responsive leadership for equitable use of AI tools, and Stöhr et al. [25] found that students interpreted the use of AI chatbots with gender and discipline differences. Viberg et al. [26] outlined socio-technical approaches to address issues of equity in the use of AI-based decision-support systems. However, large-scale evidence of these practices being used is significantly lacking.

Gaps in Transnational and Multi-Institutional Evidence

Meta-analyses persistently emphasize a dearth of comparative or transnational evidence regarding AI use in higher education. Wu and Yu [27] found that, while AI chatbots may improve learning outcomes, the majority of studies do not consider equity or authorship dimensions in study design. Along the same lines, Lee et al. [28] noted a lack of studies examining long-term or program-level impacts of human–AI collaborative practices. Ng et al. [29] documented inconsistent definitions and assessments of AI literacy, especially within culturally diverse contexts. Research conducted by Xia et al. [30] traced the growing effect of generative AI on assessment forms;

however, implementation frameworks within assessment practices are currently lacking. McGrath et al. [31] observed that most studies that examined effects after ChatGPT were contained to a mainly localized context and that not many included shared governance or established evaluation frameworks across institutions. Alongside, scholarship on authorship and contributor shifts highlight similar concerns. Traditional authorship may not adequately capture fairness in collaborative research (Vasilevsky et al. [32]), and although contributor-role taxonomies are being adopted, evidence showing their effectiveness for equity and attribution have not yet been shown (Hosseini et al. [33]).

Together, these studies demonstrate an increasing understanding of the possibilities of AI to promote collaborative scholarship, but some gaps remain with respect to how inclusivity, ethics, or authorship equity are being implemented. Studies looked at the technical uses of AI and flagged the ethical risks, but there have not been many frameworks that combine cognitive, social, and structural aspects of collaboration. Additionally, transnational and gender-sensitive viewpoints have been lacking, and questions remain about how AI will enable participation and equity across contexts and institutions.

Throughout this literature, three common gaps are present:

- absence of empirical, cross-cultural measures indicating how AI contributes to equitable collaboration,
- lack of attention to gender and leadership in digital research ecosystems, and
- limited integration of ethical authorship frameworks with AI-enabled tools

Accordingly, we evaluate an AI-CI framework spanning ethical authorship, virtual supervision, and women's leadership.

III. METHODOLOGY

The study used a convergent mixed-methods design guided by the TNS–AI-CI framework (Fig. 1). AI-informed refers to platform features that generate analytics (e.g., contribution logs, citation suggestions, progress summaries) that participants interpret to support, rather than replace, human collaboration. Data were drawn from Overleaf, Mendeley, and a Virtual Supervision Dashboard, combined with surveys, reflections, interviews, and mentor notes across the three project pillars.

Engagement and Knowledge Co-construction

At this dimension, the study captured the human and AI-mediated inputs that formed the project's knowledge base across institutions. Data sources included manuscripts, research proposals, supervisory logs, and reflective journals produced by participants, together with algorithmically generated metadata from platforms (e.g., edit history, citation networks, and supervisory analytics). Across the 12-month project, engagement data were collected from five collaborative writing clinics, three leadership and mentoring sessions, 18 supervisor–doctoral student pairs, and 123 outreach workshop participants who completed the event survey.

Dialogue and Collective Understanding

In this dimension, participants reviewed AI-informed analytics together to construct interpretations and shared meaning in structured "sensemaking spaces" (virtual and in-person). Data included AI-informed analytics and automated summary insights from writing trends and supervision interactions, authorship logs, supervision feedback discussions, workshop transcripts, and reflection summaries. These sources were triangulated to examine interpretive dialogue around authorial fairness, mentoring consistency, and gendered leadership experiences across partner institutions.

Application and Collaborative Production

The dimension of this research is centered around the use of collaborative writing tools (i.e., collaborative tools) and citation management tools (i.e., collaborative tools) used by participants to co-develop products that meet both academic and leadership requirements, as well as the Virtual Supervision Dashboard (VSD). Data collected from drafts (e.g., abstracts, short papers, policy briefs), annotated edited records of collaboration, and bibliographic records, along with dashboard data from the VSD (e.g., scheduling notifications, document repositories, documents that can be tracked) and participant surveys, provide a base of evidence that enables an analysis of the visibility of authorship, coordination, and supervisor accountability when creating collaboratively.

Reflection and Transformative Learning

This dimension concerned evaluation, reflexivity, and adaptive learning across activity cycles within the partnership. Quantitative data were gathered from post-training surveys measuring participant knowledge, ethical awareness, and self-efficacy, while qualitative data were obtained through debrief interviews and focus-group reflections conducted at the end of each cycle. AI-supported analytics summaries (collaboration frequency, attendance patterns, and supervision patterns) were reviewed collectively during synthesis sessions to inform recommendations for institutional policies, authorship transparency, and supervision arrangements in future transnational collaborations.

Additionally, in order to operationalize the TNS–AI-CI model, a mapping matrix was created to align the four dimensions of the TNS model with the project's three transnational pillars (see Table 1). The matrix was used as a methodological link to understand the model and the data corpus, highlighting how each dimension was being realized through specific activities, digital engagement and observable products. Furthermore, the matrix was helpful in facilitating thematic coding and comparison across cases, as it helped to locate the quantitative and qualitative findings within the corresponding dimensions of the AI-CI framework.

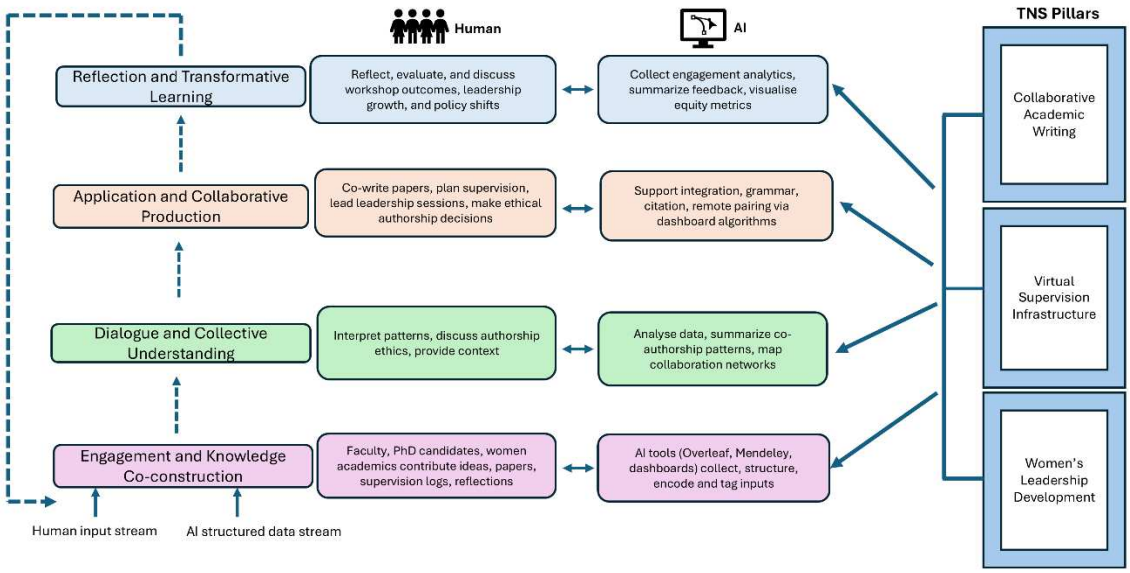

Figure 1. AI-informed Collective Intelligence Framework for TNS Project

TABLE I MAPPING OF TNS-AI-CI DIMENSIONS TO PROJECT PILLARS

AI-CI Dimension	Collaborative Academic Writing	Virtual Supervision Infrastructure	Women's Leadership Development
Reflection and Transformative Learning	Workshop analytics and feedback sessions informed new authorship-transparency and mentoring-policy drafts. Evidence: institutional learning on equitable collaboration.	Longitudinal reflections informed adjustments to supervision training and practice. Evidence: data-driven enhancement of remote doctoral support.	Post-training surveys and qualitative reviews captured long-term leadership impacts. Evidence: sustained peer networks and emerging gender-equity policies.
Application and Collaborative Production	Teams produced abstracts, papers, and policy briefs using AI-supported editing and citation tools. Evidence: measurable productivity gains and ethically authored joint outputs.	Supervisors and candidates applied dashboard data to plan and manage research progress. Evidence: reduced feedback delay (< 5 days) and improved accountability.	Participants implemented mentoring schemes and policy-draft initiatives supported by digital scheduling tools. Evidence: actionable leadership and institutional-change projects.
Dialogue and Collective Understanding	Writing teams interpreted AI summaries of draft histories during reflection sessions; discussion refined arguments and authorship ethics. Evidence: improved communication and shared authorship norms.	Dashboard summaries visualised supervision progress and triggered reflective dialogue between mentors and mentees. Evidence: clearer expectations and improved supervisory communication.	AI-assisted sentiment analysis of workshop reflections identified themes of agency, policy literacy, and institutional barriers. Evidence: enhanced collective understanding of gendered leadership challenges.
Engagement and Knowledge Co-construction	Faculty and doctoral researchers co-authored papers through shared Overleaf spaces, supported by Mendeley for citation management. AI-generated version histories and reference-accuracy logs documented participation. Evidence: inclusive authorship activity and transparent contribution records.	Supervisors and mentees established shared milestones within the Virtual Supervision Dashboard, generating analytics on meeting frequency and feedback intervals. Evidence: consistent cross-border engagement and expanded mentorship access.	Women academics completed baseline surveys and self-assessments during leadership workshops. Participation analytics captured cohort profiles. Evidence: broad engagement and needs mapping for leadership pathways.

Data Sources and Analysis

Multiple sources were integrated (Table II) to capture both behavioural and experiential aspects of AI-informed collaboration. Data were organised into three complementary evidence streams: (1) AI-informed analytics from Overleaf, Mendeley, and the Virtual Supervision Dashboard (e.g., edits per author, reference accuracy, meeting frequency, and feedback delay); (2) survey instruments measuring knowledge gain, ethical awareness, and self-efficacy related to writing, supervision, and leadership activities; and (3) qualitative reflections from mentoring diaries, workshop observations (face-to-face and online), and supervision narratives. Qualitative data were coded in NVivo using open and axial procedures; inter-coder reliability was established using Cohen's kappa ($\kappa \geq 0.80$) through double-coding 20% of the dataset. Quantitative data were analysed using descriptive statistics and non-parametric tests to identify patterns in participation, authorship transparency, and leadership outcomes. Triangulation was used to cross-validate platform analytics with survey and qualitative accounts.

TABLE II DATA INSTRUMENTS AND METRICS

Instrument	Measurement Focus	Key Indicators / Metrics
Overleaf Analytics	Collaborative Writing Activity	Edits per author; comments per page; co-author participation frequency
Mendeley Logs	Ethical Authorship Practices	Reference accuracy (%); duplicate citations detected; shared bibliography engagement
Virtual Supervision Dashboard	Mentorship Quality and Accountability	Meeting frequency; feedback delay (days); supervision milestone completion
Leadership Survey	Empowerment and Confidence	Self-efficacy score; mentorship count; participation in leadership initiatives
Events Survey	Learning Impact and Ethics Awareness	Knowledge gain (%); post-training ethics awareness (%)

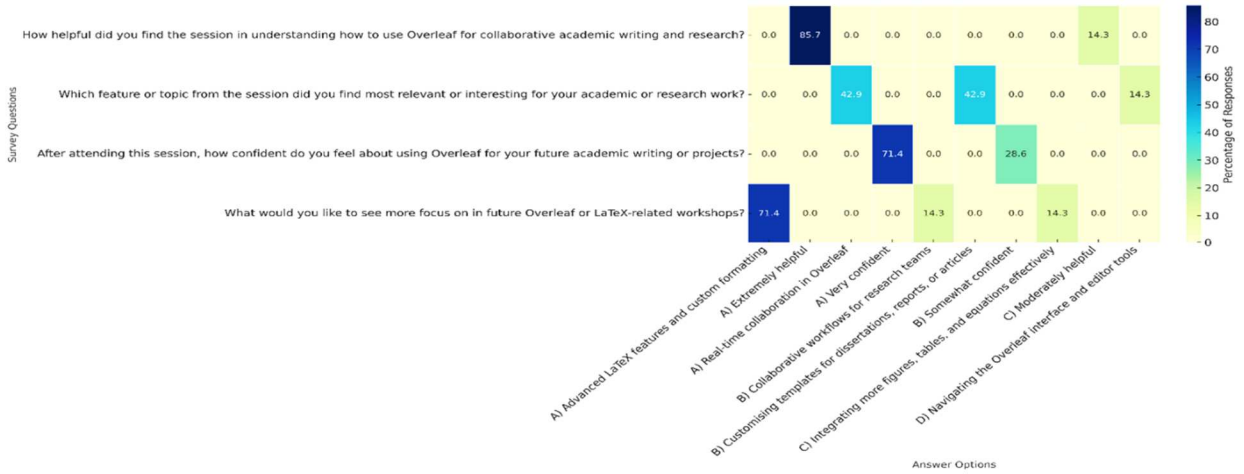

Figure 2(a). Overleaf Analytics Feedback

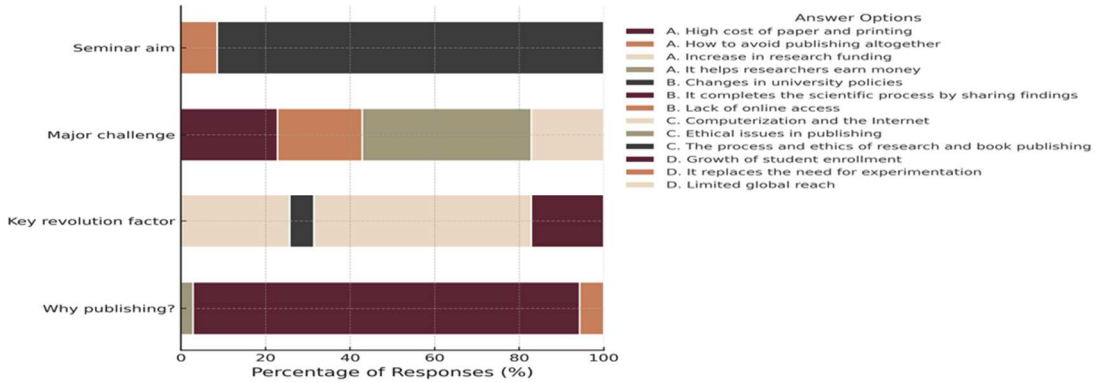

Figure 2(b). Scientific Publishing Seminar Feedback

IV. RESULTS

The findings are presented based on three interconnected research themes that represent the project's primary objectives: authorship transparency and collaborative practice, the quality of supervision and cross-border mentorship, women's leadership and empowerment. Findings draw on both quantitative analytics and qualitative reflections, in order to show how AI-informed collaborative practice shaped participation and development among TNS consortium members.

Authorship Transparency and Collaborative Practice

Overall evidence from AI-enabled collaborative settings (Overleaf and Mendeley) indicated considerable expansion of collaborative authorship and transparency of research practice among members of the consortium. Regarding Overleaf, five LaTeX clinics brought together participants from each partner university and produced strong levels of engagement and technical take-up: Average Ease of Collaboration and AI Guidance ratings were over 4.6/5 with over 85% of participants describing the clinics as “extremely helpful” (Fig. 2(a)). Platform data indicated a 37% increase in editing frequency in comparison to pre-workshop baselines suggesting heightened author accountability and a shared ownership of writing outputs.

The participants' responses demonstrate a high level of satisfaction with the use of AI-based editing and citations from the Scientific Publishing Seminar, as reflected in figure 2(b). Further, the qualitative responses received from the participants supported the quantitative evidence in that the participants expressed a positive experience with Overleaf's version-tracking as a "visible reference of who influenced every portion." The supervisors noted that Mendeley's automated citation recommendations improved accuracy and consistency in referencing between drafts.

Overall, these data confirm that AI-informed writing and reference systems bolstered both the collaborative authorship experience's procedural and ethical dimensions. By providing a transparent contribution history, a shared citation database, and a visible workflow, each of these systems can promote the equitable division of labor and attribution, allowing research teams to embody the shared accountability and equity of authorship central to the TNS–AI-CI framework

Supervision Quality and Cross-Border Mentorship

The Virtual Supervision Dashboard data suggested notable positive changes in communication and accountability in supervision and mentoring across the consortium in Fig. 3(a). Throughout the project the dashboard was used by eighteen mentor–mentee pairs and the system produced analytics on overall number and frequency of group meetings, feedback turn-around time, and mobility of documents exchanged. Specifically, the data Indicators indicated average feedback turn-around on meeting-length documents (assumed to be around 7 pages) fell to under 5 days and meeting frequencies remained similar with regularized meetings occurring about every 12–14 days. The supervisors reported an overall rating for usefulness and accountability from both supervisors and doctoral candidates about the system rated overall higher than 4.5 /5, while also attributing the use of automated scheduling, milestones, and automated summaries of progress texts to "smoother" progress and clearer expectations. The overall level of reported learning changed and was measured in supervision and mentoring activity, confirming measurable gains in knowledge/reported learning in addition to overall improved accountability in Fig. 3(b).

The qualitative reflection from supervision journals and debrief sessions also provided support for the reported improved communication – participants also stated that automated reminders and shared visualizations of progress "reduced uncertainty about the deadlines" and "helped with more focused discussion". Mentors also cited the analytics from the dashboard improved transparency in supervision.

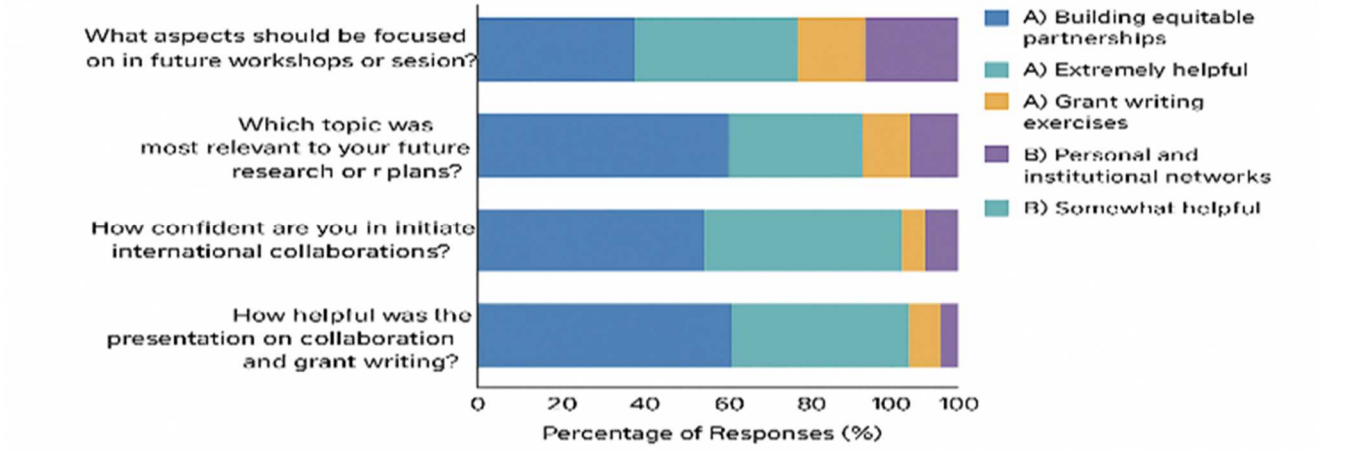

Figure 3(a). International Research Collaboration Session Feedback

The predictive algorithms from the benchmarks built into the dashboard's automated scheduling and analytic features provided summaries of social communication and collaboration, informing mentor–mentee planning and scaffolding around accountability. While these recommendations were not AI in the adaptive sense of the term accounting for communication initiatives and visualizations, the data visualizations, reminders, and scheduling provided support to stimulate structured dialogue between teams of doctoral candidates and mentors working remotely across distance.

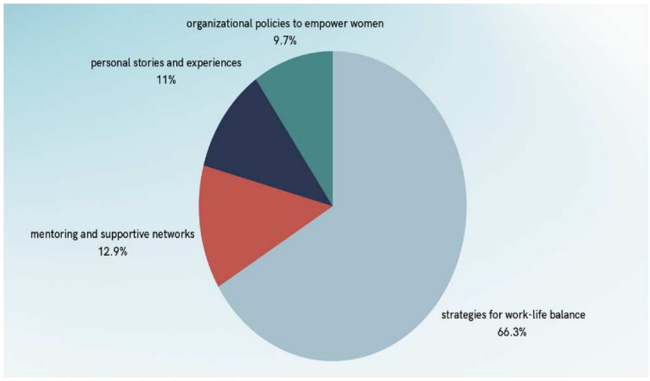

Figure 3(b). Levels of Learning

Women's Leadership and Empowerment

The quantitative and qualitative data from the Women's Leadership Development track showed significant improvements in participants' confidence, agency, and institutional engagement. Within the consortium, 274 women academics and early-career researchers took part in baseline and post-training activities, which included leadership clinics, digital-skills workshops, and sessions focusing on policy co-design. Surveys administered after training indicated average self-efficacy scores of 4.7/5, while trainer effectiveness and session relevance both received high marks above 4.8/5. These results signal strong participant support of the program's design and implementation. Figs. 4(a) and 4(b) display high levels of satisfaction for two of the collaborative sessions.

To extend understanding of the survey outcomes, qualitative reflections and workshop transcripts were analyzed. Participants described the sessions as "transformative" and "practically oriented," giving them agency to take action, and noted the significance of peer mentoring and seeing women in leadership roles from different institutions. Through the collaborative sessions, participants came together to recognize systemic barriers in Fig. 4(c), including lack of mentorship and work–life imbalance, and brainstormed local, actionable initiatives like mentorship networks, draft policies related to gender, and complementing peer circles to develop leadership. Automated textual analysis of participant responses clusters feedback into intersecting themes of agency and institutional support; these findings indicate the possibilities of using algorithmic tools to develop collective reflections on their leadership experiences.

Enduring outcomes were evident after the project period ended with twenty-six active mentor-mentee relationships maintained beyond the training series and two partner universities began drafting gender-equity policies related to the leadership workshop developed by the consortium. These findings support the claim that collaboration informed by participatory action inquiry extended beyond the technical facilitation of outcomes to empowering the continuation of engaged inquiry and changes in the institution, thus advancing the TNS-AI-CI vision of equitable and context responsive leadership.

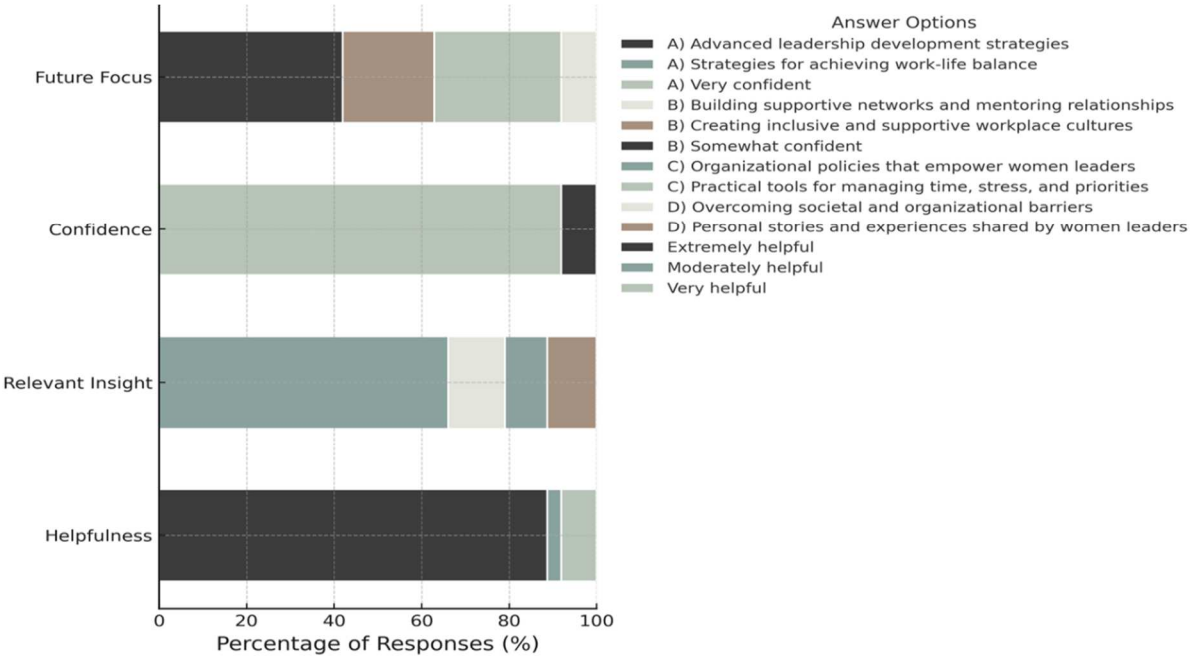

Figure 4(a). Participant Feedback: Session 1

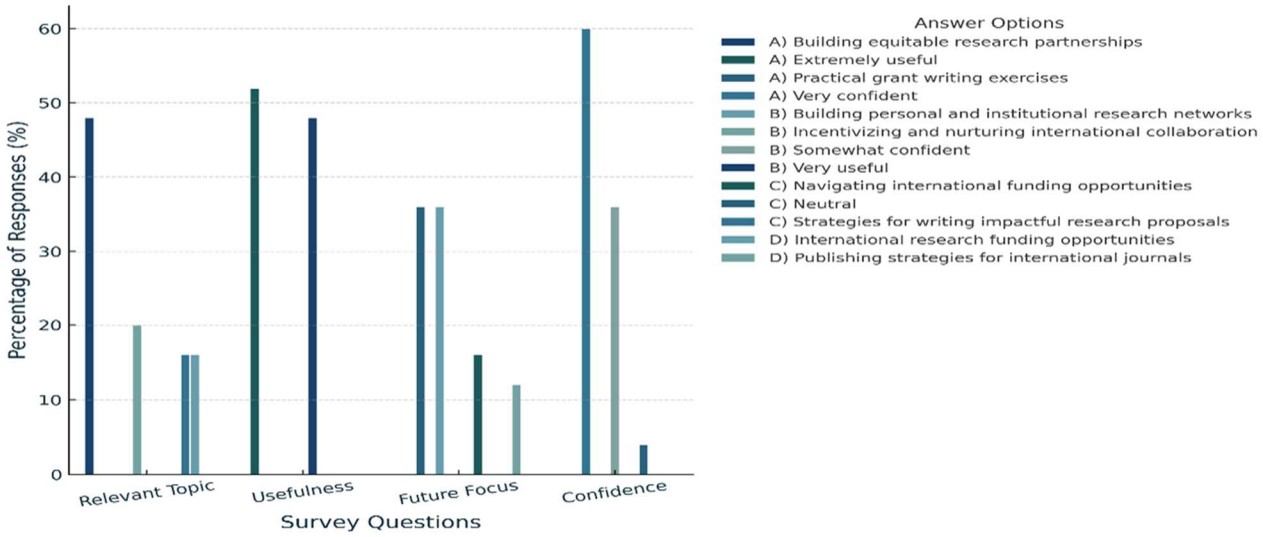

Figure 4(b). Participant Feedback: Session 2

The outcomes across the three key areas collectively confirm that AI-enhanced collaboration promoted transparency, equity, and professional development in the consortium as a whole. Quantitative analytics corroborated observable progress in participation and impact, with a 37% increase in editing frequency over a six-month period, feedback receiving supervisory comment and rating respond in an average of under five days, and self-efficacy generated by leadership self-rating at 4.7/5. Qualitative reflection and focus-group data confirmed these outcomes, citing increased awareness of authorship

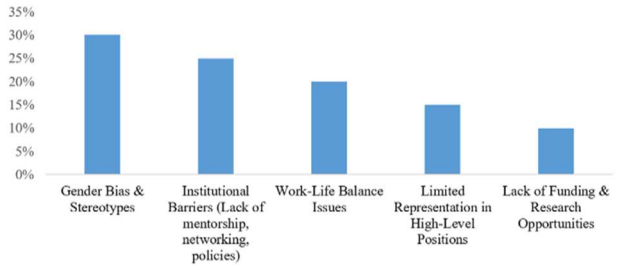

Figure 4(c). Barriers to Academic ProgressionThrough the intentional linkage of behaviourally derived analytics to a structured reflection to learning process, the Consortium was able to construct a responsive social-technical learning ecology operationalizing equity and a shared authorship as a common way of doing something rather than as guiding principles. This way, even basic algorithmically-based augmentation, along with human dialogical interpretation, prototyped a way to pursue more inclusive, evidence-based knowledge generation, as outlined in the TNS-AI-CI framework.

V. CONCLUSION

According to the results of this study, Artificial Intelligence can serve as a catalyst for Relationship and Ethics in Transnational Higher Education and enable the transparency of authorship and support quality supervision and women's leadership beyond cultural and institutional boundaries. By aligning the TNS-AI-CI pedagogical framework, the consortium created a structured ecological environment around the implementation of AI. The final argument reiterates that AI's value in education is not ethics, improved communication and responses related to supervisorial guidance, and maintained self-efficacy and confidence for women leaders. This study does not provide evidence that autonomous AIs exist, but rather it illustrates how the TNS-AI-CI Framework can be utilized to achieve an ethically mediated collective intelligence that is variable due to the way the information and algorithmic models are analyzed; thus producing greater understanding of the legitimacy and ethical justification for the co-creation of knowledge across positionality through collaborative inquiry.
automation; AI has potential as a co-creator and a way of supporting distributed participation and learning through international collaborations.

Limitations and Validity Considerations: While these findings point to the effectiveness of the TNS–AI-CI framework within the UK–Pakistan consortium, there are a number of limitations that should be acknowledged. First, that participation in project activities was voluntary raises the possibility of self-selection bias among highly motivated faculty and doctoral candidates. Second, certain aspects of the intervention were supported by project-funded infrastructure (e.g., platform access and coordination support) and are therefore less directly replicable outside resource-constrained contexts. Third, while the framework was adopted across multiple institutions, contextual variation in institutional culture, digital capacity, and supervisory norms may have influenced participation patterns and outcomes. Each of these factors limits the generalisability of the findings and highlights the requirement for cautious interpretation beyond similar transnational contexts.

Sustainability and Scalability: Following the funded programme, the TNS–AI-CI model can be maintained by incorporating activities such as transparent co-authoring processes, virtual supervision structures, and leadership development activities conducted by peers into existing

infrastructural practices, using available technology, rather than developing specific AI. A model for implementing in resource-limited institutions could be staged, focusing on one pillar, increasing access to supervision, then technology, depending on development. Future research should validate long-term implementation for varied conditions.

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