IEICE TRANS. INF. & SYST., VOL.E107–D, NO.4 APRIL 2024

PAPER *Special Section on Information and Communication Technology to Support Hyperconnectivity*

Conversational AI as a Facilitator Improves Participant Engagement and Problem-Solving in Online Discussion: Sharing Evidence from Five Cities in Afghanistan

Sofia SAHAB[†a)], **Jawad HAQBEEN**[†], ***Nonmembers***, ***and*** **Takayuki ITO**[†], ***Member***

SUMMARY Despite the increasing use of conversational artificial intelligence (AI) in online discussion environments, few studies explore the application of AI as a facilitator in forming problem-solving debates and influencing opinions in cross-venue scenarios, particularly in diverse and war-ravaged countries. This study aims to investigate the impact of AI on enhancing participant engagement and collaborative problem-solving in online-mediated discussion environments, especially in diverse and heterogeneous discussion settings, such as the five cities in Afghanistan. We seek to assess the extent to which AI participation in online conversations succeeds by examining the depth of discussions and participants' contributions, comparing discussions facilitated by AI with those not facilitated by AI across different venues. The results are discussed with respect to forming and changing opinions with and without AI-mediated communication. The findings indicate that the number of opinions generated in AI-facilitated discussions significantly differs from discussions without AI support. Additionally, statistical analyses reveal quantitative disparities in online discourse sentiments when conversational AI is present compared to when it is absent. These findings contribute to a better understanding of the role of AI-mediated discussions and offer several practical and social implications, paving the way for future developments and improvements.

key words: *conversational AI, online forum, discussion support, user research, problem-solving, consensus informatics*

1. Introduction

The emergence of the internet has given rise to web-based discussion support systems, which hold immense promise for fostering democratic social interactions in the realm of electronic (e)-participation [1]. E-participation, an innovative approach that harnesses electronic media with machine-assisted support, offers solutions to the challenges associated with traditional participation processes [2], [3]. In this digital age, technology-enabled communication has become central to human life, playing a pivotal role in facilitating collaborative interactions among citizens.

Nearly two decades ago, Thomas W. Malone, based at the MIT Center of Collective Intelligence, envisaged a future where interactions would be fundamentally transformed by collective information gathering and the collaboration between humans and machines [4]. In this context, the ability of machines to reason and communicate with humans becomes indispensable. It opens doors to extracting valuable insights from individuals by tapping into the collective wisdom of diverse stakeholder groups in online forums.

A substantial portion of online communication now revolves around text-based discussions, where individuals converge on digital platforms to deliberate on common issues. This represents a significant step forward, offering an alternative and more meaningful mode of engagement compared to traditional face-to-face participation processes [3]. Importantly, it creates opportunities for collaboration between humans and machines, ushering in a new era of cooperation.

Numerous systems have been developed to facilitate idea generation and policy discussions on a large scale, particularly in question-answering formats [1], [5]–[7]. The facilitation of extensive public participation in discussions has paved the way for inclusive decision-making, a feat previously unattainable through conventional means.

The increasing evolution of technologies to support online discussion has resulted in cutting-edge advances in recent years, with artificial intelligence (AI) leading the pack. Machine agency, and in particular, conversational AI systems, have expanded the horizons of collaborative interaction between humans and computers for the greater social good [8]. Conversational AI, defined as a program designed to interact with humans using natural language, mimics the processes of human conversational intelligence. As conversational AI becomes increasingly integrated into online forums, it necessitates the evolution of multidisciplinary research to explore its practical and societal implications [9].

While conversational AI capable of understanding and intelligently conversing with humans has existed since the 1960s [8], the concept of creating programs that can effectively facilitate and support online group discussions while mimicking human conversational intelligence was introduced by Ito et al. in 2018 [1].

As conversational AI assumes the role of facilitator and incorporates advanced techniques like machine learning (ML) and deep learning (DL), there is a growing imperative to evolve user studies for a comprehensive assessment of their broader social impact. Previous research has made valuable contributions to this field [1], [10], yet it faced limitations in terms of scope, primarily focusing on single-city contexts. To address these constraints, our study extends and validates these findings. Specifically, we conducted our research in Afghanistan, encompassing five cities characterized by diverse socio-economic profiles and significantly

Manuscript received June 2, 2023.
Manuscript revised October 13, 2023.
Manuscript publicized January 15, 2024.

[†]The authors are with Kyoto University, Kyoto-shi, 606–8501 Japan.
a) E-mail: sahab.sofia@i.kyoto-u.ac.jp

DOI: 10.1587/transinf.2023IHP0014

expanding our participant pool. This expansion contributes to a more comprehensive understanding of conversational AI's role in shaping online discourse and enriches the academic discourse on the influence of AI involvement within diverse and dynamic settings, emphasizing the importance of context-specific validation in scientific inquiry.

1.1 Research Objectives and Hypotheses

The primary objective of this study is to examine the impact of conversational AI on enhancing participant engagement and fostering collaborative problem-solving within online-mediated discussion environments, with a particular emphasis on diverse and heterogeneous discussion settings, notably the five cities in Afghanistan. To address these overarching research objectives, this study explores the following research questions:

1. Does the integration of conversational AI into text-based interactions contribute to and facilitate user engagement within online-mediated discussion environments across various venues, particularly in regions characterized by diversity and conflict, such as Afghanistan?
2. Does conversational AI have the capacity to support and influence the formation and transformation of opinions towards a positive disposition across diverse venues?

To explore these questions, we conducted a comprehensive study over a 30-day period, involving participants from five cities in Afghanistan. Participants were directed to interact in D-Agee, an AI-powered online discussion forum. Our study encompassed an examination of participants' performance and informetric activity, comparing discussions facilitated with conversational AI and those without.

In alignment with the research questions outlined above, we propose the following hypotheses to guide our investigation:

H1: The use of conversational AI as a facilitator in text-based online group discussions is expected to significantly enhance user engagement across various venues, particularly in diverse and conflict-affected regions like Afghanistan. This enhancement is anticipated to result in a higher number of posts per participant in AI-facilitated discussions compared to those conducted without AI facilitation.

H2: The use of conversational AI as a facilitator in text-based online group discussions is expected to significantly enhance the focus on problem-solving aspects in discussions across various venues. This enhancement is anticipated to result in a higher number of ideas in AI-facilitated discussions compared to those conducted without AI facilitation.

H3: The use of conversational AI as a facilitator in text-based online group discussions is expected to significantly increase the exploration of benefits and drawbacks associated with solutions generated across various venues. This enhancement is anticipated to result in a greater number of pros and cons being discussed in AI-facilitated discussions compared to those conducted without AI facilitation.

By pursuing these hypotheses, our research aims to make meaningful contributions to the existing body of knowledge, enriching our understanding of the role played by AI mediation in shaping citizen opinion formation and its potential implications for participatory decision-making processes.

The findings of this study contribute to the community in three significant ways. Firstly, it enhances our understanding of human users' dynamics in conflict-affected regions, such as Afghanistan, when using conversational AI as a facilitator to engage in problem-solving text-based debates and influence opinions across diverse venues for Social Goals (SG) [11]. Secondly, it provides valuable insights that can be applied to informed policymaking and the design of the next generation of context-specific conversational AI applications. Thirdly, this case study aligns closely with the principle of 'leaving no one behind' (LNOB), which constitutes the central, transformative commitment of the 2030 Agenda for SDGs, offering sustainable practical and social implications.

The remainder of this paper is organized as follows: Sect. 2 surveys existing research work on discussion support systems and user studies. Section 3 presents the proposed methodology, including sample selection, data collection instruments, and data analysis methods. In Sect. 4, we present the results of the cross-venue experiment with and without a conversational agent. Lastly, Sect. 5 discusses the implications, draws conclusions, and suggests future research directions.

2. Related Work

In recent years, the concept of crowdsourcing has garnered the attention of scholars across diverse academic disciplines who are driven by a shared goal: to explore, analyze, comprehend, and potentially enhance this burgeoning labor paradigm [12]. Crowdsourcing involves the strategic transfer of tasks that were once the domain of in-house personnel to an amorphous and often extensive collective of individuals through open solicitations [13].

In their comprehensive literature review, Hossain and Kauranen (2015) [14] meticulously compiled an inventory of diverse crowdsourcing applications, encompassing idea generation, micro-tasking, open-source software development, public participation, citizen science, citizen journalism, and collaborative wikis. Their exhaustive analysis of keywords in relevant articles illuminated the academic domains in which crowdsourcing has been systematically examined, revealing recurrent terminology such as social, Web, innovation, open, information, human, online, community, mechanical, collective, and networks [14].

The advancement of crowdsourcing in recent years has enabled substantial internet-based collaborations and the emergence of renowned platforms for collective intelli-

gence, empowering both individuals and groups to exchange knowledge, tackle intricate issues, and reach informed decisions through web-mediated interactions and collaborations [15]. One such platform is "MIT Climate CoLab," an online crowdsourcing forum launched in 2009 to address climate change through human-machine collaboration [5], [16]. It has demonstrated its effectiveness in fostering contributions and decision-making within the context of climate change, with an emphasis on the repercussions of individual actions [17]. However, it is noteworthy that the process on Climate CoLab is overseen by human experts, which may lead to scalability challenges.

Another work from MIT is "Collaboratorium," which proposes an online platform for organizing discussions using argumentation maps to frame ideas within a given discussion structure [18]. However, they conducted argumentation manually using human-assisted skills, leading to issues such as a heavy burden on human annotators and potential annotation bias.

An open web-based forum called "COLLAGREE," designed in 2013, supports online discussions with features such as (human) facilitator support, a point-ranking system to incentivize participation, and hierarchical post organization [19]. Various studies [20]–[23] build upon this research and conduct social experiments to evaluate the system's acceptability [24]–[28]. Simultaneously, some researchers [29], [30] contended that relying solely on human facilitators introduced challenges such as decision-making burdens and inherent facilitation biases. In response, Ito et al. [1], [31] explored the potential of conversational AI as an autonomous facilitator in online forums, aiming to mitigate these issues.

In 2018, Ito et al. [31] introduced the integration of conversational AI to enhance the organization of large-scale online discussions, driven by concerns related to human facilitation bias and scalability challenges. This pioneering initiative marked the inception of a broader trend wherein conversational agents, notably chatbot facilitators, opened up new avenues for the exploration of human-machine collaboration behaviors [10], [32]–[35]. While numerous studies have examined the effectiveness of the D-Agree platform [32]–[35], a limited number have delved into the efficacy of conversational AI by comparing scenarios involving it with those without, or using human facilitators. Notably, two pivotal studies that contributed to understanding the impact of conversational AI facilitation are those conducted by Ito et al. [1] and Rafik et al. [10].

In the pilot study by Ito et al. [1], conducted in Nagoya, Japan, researchers compared the effectiveness of human facilitators and AI facilitators in online discussions. Their findings revealed that conversational AI facilitators exhibited a higher degree of efficacy in stimulating participation and enhancing engagement [1]. Similarly, Hadfi et al. [10] delved into this concept, conducting a user study in Kabul, Afghanistan, wherein they compared discussions with and without conversational AI facilitation. Their results underscored the positive impact of conversational AI-mediated discussions on the development of constructive discourse [10]. However, it is essential to note that both studies were confined in scope and analysis to a single city, thereby potentially limiting the generalizability of AI facilitation's influence in online forums.

The current study extends beyond these constraints by encompassing five cities, each characterized by distinct socio-economic profiles. This multi-city approach allows for a more comprehensive assessment of the impact of conversational AI facilitation in online forums and offers insights into potential contextual variations. Furthermore, we have significantly expanded our participant pool, involving a larger and more diverse set of individuals compared to previous research efforts. This expansion enhances the overall robustness and validity of our research findings and contributes to a more comprehensive understanding of the role played by conversational AI in shaping online discourse. This methodological approach aligns with established academic practices, emphasizing the importance of replicating studies across diverse contexts to yield nuanced insights and bolster the credibility of research findings [36].

3. Methods

Our general methodology is to adopt an exploratory quantitative cross-venues case study, with a specific focus on problem-solving conversations, employing a conversational AI as a facilitator. Specifically, this case study follows online communities of five major provincial capital cities of Afghanistan through open-call and Facebook Ads for 30 days while requesting them to engage in problem-solving conversation using D-Agree. The study consisted of two equal phases of discussion: non-mediated and AI-mediated and utilized D-Agree as the discussion instrument. Subsequent subsections provide more detailed information on each of these aspects of the study.

3.1 Study Area

The study was conducted in five major provincial capital cities of Afghanistan: Kabul, Herat, Mazar-i-Sharif, Kandahar, and Jalalabad. These cities exhibit diverse socio-economic characteristics, with variations in economic well-being, employment opportunities, access to services, household sizes, literacy rates, internet accessibility, and predominant ethnic groups [37], [38].

Afghanistan is divided into 34 administrative provinces, each with a provincial capital city and further divided into provincial districts. Kabul, the capital and largest city of Afghanistan, located in eastern Afghanistan, has the largest land area (1,049 km^2) and highest population (3,564,855) of any Afghan city. Herat, the second largest city, is a regional hub located in the western part of the country, close to the borders with Iran and Turkmenistan. Mazar-i-Sharif, the third largest city, is a regional hub located in the northern region of Afghanistan, in close proximity to Uzbekistan and Tajikistan. Kandahar, a regional hub in

southern Afghanistan, is situated near the border with Pakistan, while Jalalabad, a regional hub in eastern Afghanistan, is also located close to the border with Pakistan [38], [39].

3.2 Participants

Participants were recruited through an open call on D-Agree's Facebook page, boosted by paid ads targeting the five major provincial capital cities of Afghanistan: Kabul, Herat, Mazar, Kandahar, and Jalalabad. A total of 749 participants from these cities took part in the study. Those who were interested and had access to the internet participated in the experiment. Incentives for participation included a participation certificate for the top three discussants with the highest system scoring during the two phases. Demographic information of the participants was not collected to avoid causing concerns among potential participants about the use of their personal information, especially given that the experiment was conducted during a sensitive period, a few months after a government transition, which might have discouraged participation. Nevertheless, based on participants' chosen nicknames, we estimated that 614 were male (81.98%), 116 were female (15.49%), and 19 (2.54%) had names that made gender estimation difficult.

3.3 Procedures

The study consisted of two phases of discussion: (i) non-mediated discussion and (ii) AI-mediated discussion. Both phases lasted for 15 days each, from January 12 to January 27, 2022, and from January 27 to February 11, 2022, respectively. A Facebook Ad was used to target each of the five cities mentioned in the study, with a link to the corresponding discussion space for that city.

Participants who clicked on the link were directed to the discussion space for their city and were required to agree to the consent form before entering the space. They could log in to D-Agree through their Facebook, Gmail, or Twitter accounts. Once inside, participants could post their opinions, reply to other opinions, and like posts. For the non-mediated discussion, the AI was not activated to lead the discussion. However, for the AI-mediated discussion, the AI was used to facilitate the discussions among citizens. The discussion theme was set as "What are the opportunities and challenges of [city name]?".

3.4 Ethical Consideration

The experiment was conducted with the approval of the Ethics Committee of the Graduate School of Informatics, Kyoto University (KUIS-EAR-2021-020). Informed consent was obtained from participants upon entering the discussion space in D-Agree. The study team took all necessary steps to ensure the ethical conduct of the study.

3.5 Discussion Instrument

The study utilized D-Agree as the discussion instrument, which is an online text-based discussion support system composed of an artificial agent and a web platform that allows participants to exchange messages with each other and with the conversational AI. The automated facilitation agent performs several tasks, including observing the textual content posted by users, extracting argumentative utterances from the content based on Issue-based Information System (IBIS), generating facilitation messages based on predefined rules, and posting the messages to the discussion board in response to other posts [1].

The use of IBIS [40], allows for the extraction of the discussion structure and helps lead the discussions while allowing participants to clarify issues and ideas and then debate their merits and demerits. The facilitation agent incentivizes participants to cover more issues, ideas, pros, and cons by posting facilitation messages related to the discussion [1].

To incentivize participation and stimulate efficient communication and collaboration among participants, D-Agree rewards users with two types of points: active points derived from their own posting activities, such as creating new items, replying to their own or other posts, and liking other posts, and evaluated points earned from the likes and replies their posts receive from other users. They are ranked based on these points in real-time, which is displayed on the user interface [21].

As mentioned before, the study had two discussion settings: AI-mediated and non-mediated. In the AI-mediated setting, the AI agent facilitated the discussions, while in the non-mediated setting, the agent facilitation function of D-Agree was turned off, and participants could only discuss with each other without any type of facilitation.

3.6 Data Analysis

The data collected from the participants' discussions in D-Agree was subjected to a comprehensive analysis to investigate the impact of conversational agents on citizen opinion formation in participatory platforms. Specifically, two types of data were analyzed in this study: the number of opinions per participant and the opinions classified by D-Agree into distinct categories, including issues, ideas, pros, and cons. These data were crucial in examining the patterns and trends in participant responses and assessing any differences in opinion distribution between the AI-mediated and non-mediated settings.

Descriptive statistics, such as frequency counts, means, and standard deviations, were used to summarize and compare the data. Additionally, inferential statistical techniques were employed to examine the significance of observed differences between the two discussion settings. For comparing means between two groups (e.g., comparing the number of opinions in AI-mediated and non-mediated settings), t-tests were utilized. To analyze differences in opinion distribution across multiple groups (e.g., issues, ideas, pros, and cons), Multivariate Analysis of Variance (MANOVA) was employed.

In cases where the assumption of homogeneity of vari-

ance was violated, Welch's test was used. Furthermore, to address violations of the assumption of equal covariance matrices in the multivariate analysis, Pillai's trace was utilized as a more robust measure.

The statistical analysis was conducted using IBM SPSS Statistics version 28.0.1.1 (14). This software facilitated the necessary calculations and generated exact statistics for F values, ensuring accurate determination of the significance of observed differences. The significance level was set at $p < .05$, indicating a 5% probability of obtaining the observed results by chance.

During the data analysis, it was noted that three extreme outliers with post counts of 105, 122, and 171 were observed in the Kabul City dataset. These outliers significantly deviated from the mean post count of 2.9 (including outliers). Consequently, a sensitivity analysis was conducted by excluding these outliers, which did not significantly affect the observed differences between the AI-mediated and non-mediated settings in terms of the number of posts per participant ($p > .05$). This indicates that the conclusions regarding participant engagement remained robust, irrespective of the presence or absence of these outliers.

Similarly, the exclusion of outliers had a negligible impact when examining the differences in classified opinions (issues, ideas, pros, and cons). Thus, the findings related to participants' classified opinions were found to be reliable, regardless of the presence or absence of outliers. These results underscore the importance of considering outliers in the analysis and highlight the need to account for other factors that may influence participant behavior. By excluding these extreme values, a more accurate understanding of the relationship between the AI mediation setting and participant engagement in Kabul City was obtained.

In summary, the data analysis procedures provided valuable insights into the impact of conversational agents on citizen opinion formation. The statistical techniques employed, including t-tests, MANOVA and Welch's test, ensured a comprehensive examination of the data and determination of significant differences. The findings derived from this analysis contribute to a deeper understanding of the role of AI-mediated discussions in participatory platforms.

4. Results

We compared the number of posts by participants in AI-mediated and non-mediated discussions across all cities (see Fig. 1). In the combined dataset, there was a significant increase in the number of posts per participant when AI mediation was present ($t(744) = -4.330$, $p < .001$). This finding signifies that AI facilitation played a vital role in enhancing participant engagement, fostering a more active and dynamic discussion environment, which supports Hypothesis 1. The higher number of posts indicates that AI facilitation effectively stimulated participants to express their thoughts, opinions, and ideas. It created a conducive atmosphere for meaningful dialogue, information exchange, and active participation [41], [42]. Further analysis revealed

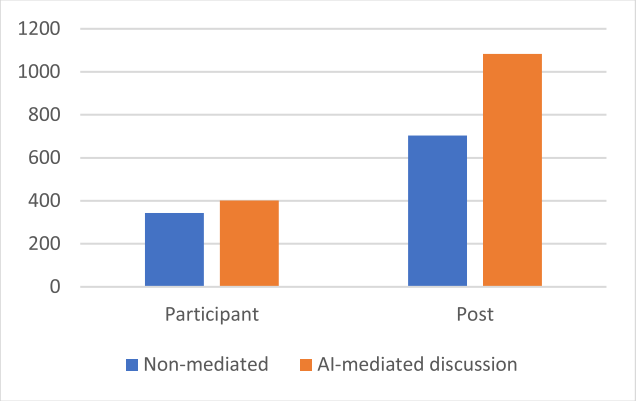


Fig. 1 Comparison of participants and posts in non-mediated and AI-mediated discussions.

significant increases in the number of posts per participant in Herat ($t(116) = -2.544$, $p = .012$), Mazare-sharif ($t(159) = -3.728$, $p < .001$), and Jalalabad ($t(82) = -6.447$, $p < .001$), further emphasizing the positive impact of AI facilitation on engagement in these cities. The results of the statistical tests are summarized in Table 1.

We then examined the classified opinions by AI into issues, ideas, pros, and cons for both the non-mediated and AI-mediated settings. The mean scores for these classified opinions in non-mediated and AI-mediated discussions across the five cities are illustrated in Fig. 2. A multivariate analysis of variance (MANOVA) conducted on the combined dataset of all cities revealed significant differences in the combined dependent variables among the two conditions (Pillai's trace $V = .080$, $F(4, 741) = 16.141$, $p < .001$, partial $\eta^2 = .080$). Pairwise comparisons of the mean scores between the non-AI-facilitated and AI-facilitated discussions showed significant increases in the classified opinions for idea ($F(1, 556) = 32.458$, $p < .001$), pros ($F(1, 679) = 30.457$, $p < .001$), and cons ($F(1, 653) = 16.365$, $p < .001$), confirming Hypotheses 2 and 3. However, no significant increase was found for the issue category ($F(1, 738) = 2.081$, $p = .150$). These results suggest that the AI effectively encouraged participants to generate a diverse range of opinions and express their viewpoints, in line with our research questions. The increase in the number of ideas suggests that AI facilitation fosters a more creative and innovative discussion environment [43]. The higher number of pros and cons signifies a more thorough exploration of the advantages and disadvantages associated with different viewpoints or decisions [44]. AI mediation can facilitate a structured analysis of the benefits and drawbacks, enabling participants to make more informed and balanced assessments. This can lead to better-informed decision-making and policy development.

Further analysis was conducted on the classified opinions for each of the five cities separately. MANOVA conducted on each city's dataset revealed significant differences in the combined dependent variables among the two conditions in all cities except Kandahar City ($p < .05$ for Kabul City, Herat, Mazare sharif, and Jalalabad). Pairwise compar-

Table 1 Comparison of variable means and test statistics between no mediation and AI mediation conditions (per participant).

Variable	Sample	Mean (NM)	Mean (AM)	Test Statistic	*p*-value	
Posts	All cities	2.05	2.69	t(744) = -4.33	<0.001	***
Posts	Kabul	2.78	2.83	t(148) = -0.14	0.891	
Posts	Herat	1.98	3.09	t(116) = -2.54	0.012	*
Posts	Mazare-sharif	1.78	2.39	t(159) = -3.73	<0.001	***
Posts	Kandahar	1.83	2.36	t(79) = -1.58	0.118	
Posts	Jalalabad	1.31	2.58	t(82) = -6.45	<0.001	***
Classified posts	All cities			F(4, 741) = 16.14	<0.001	***
Idea	All cities	0.08	0.33	F(1, 556) = 32.46	<0.001	***
Issue	All cities	0.1	0.14	F(1, 738) = 2.08	0.15	
Pros	All cities	0.08	0.23	F(1, 679) = 30.46	<0.001	***
Cons	All cities	0.04	0.13	F(1, 653) = 16.37	<0.001	***
Classified posts	Kabul			F(4, 254) = 3.04	0.018	*
Classified posts	Herat			F(4, 113) = 4.07	0.004	**
Classified posts	Mazare-sharif			F(4, 156) = 6.07	<0.001	***
Classified posts	Kandahar			F(4, 76) = 1.96	0.109	
Classified posts	Jalalabad			F(4, 122) = 4.12	0.004	**
Idea	Kabul	0.17	0.36	F(1, 250) = 5.76	0.017	*
Issue	Kabul	0.15	0.14	F(1, 214) = 0.01	0.935	
Pros	Kabul	0.16	0.26	F(1, 253) = 3.31	0.07	
Cons	Kabul	0.06	0.17	F(1, 254) = 5.62	0.018	*
Idea	Herat	0	0.41			
Issue	Herat	0.06	0.12	F(1, 115) = 1.49	0.224	
Pros	Herat	0.06	0.24	F(1, 94) = 6.45	0.013	*
Cons	Herat	0.02	0.12	F(1, 86) = 4.20	0.043	*
Idea	Mazare-sharif	0.08	0.41	F(1, 119) = 12.36	<0.001	***
Issue	Mazare-sharif	0.1	0.26	F(1, 138) = 4.45	0.037	*
Pros	Mazare-sharif	0.05	0.24	F(1, 133) = 11.01	0.001	***
Cons	Mazare-sharif	0.03	0.14	F(1, 124) = 5.98	0.016	*
Idea	Kandahar	0.07	0.21	F(1, 50) = 1.58	0.214	
Issue	Kandahar	0.14	0.03	F(1, 46) = 1.30	0.261	
Pros	Kandahar	0.02	0.15	F(1, 50) = 4.24	0.045	*
Cons	Kandahar	0.05	0.1	F(1, 59) = 0.62	0.435	
Idea	Jalalabad	0.01	0.15	F(1, 69) = 6.19	0.015	*
Issue	Jalalabad	0.01	0.05	F(1, 90) = 1.20	0.277	
Pros	Jalalabad	0.01	0.17	F(1, 70) = 8.94	0.004	**
Cons	Jalalabad	0.04	0.08	F(1, 108) = 0.77	0.384	

Note: All variables in this table represent values calculated on a per-participant basis., NM stands for No mediation and AM stands for AI mediation, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

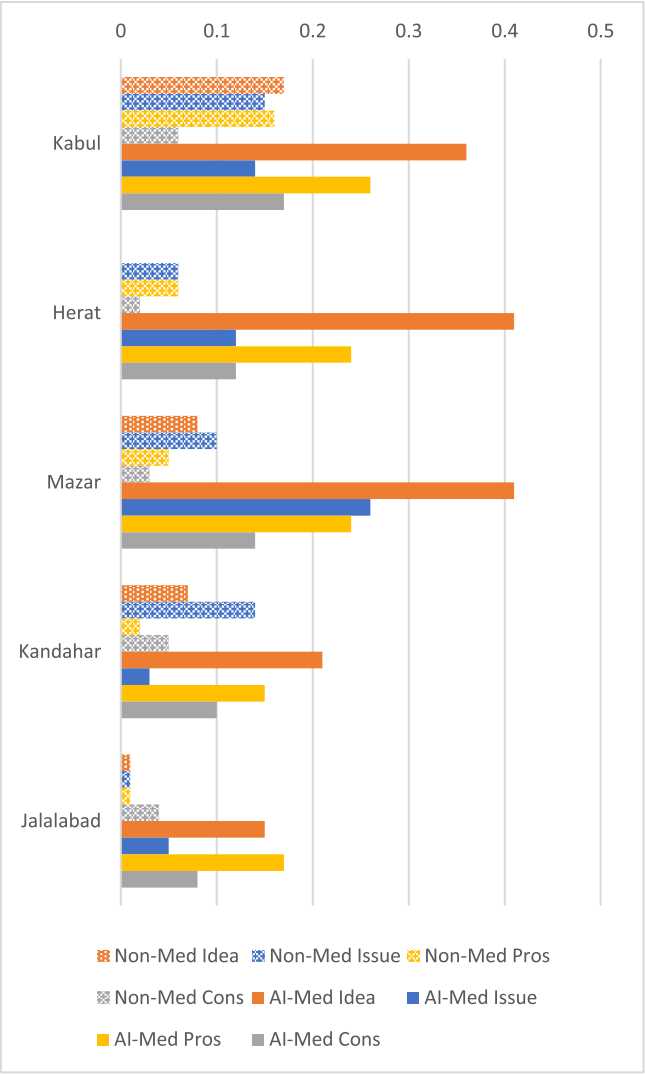


Fig. 2 Mean scores of classified opinions (Issue, Idea, Pros, Cons) in non-mediated and AI-mediated discussions across five cities.

isons of the mean scores between the non-AI-facilitated and AI-facilitated discussions showed that the idea was significantly increased with AI mediation in Kabul, Mazare-sharif, and Jalalabad ($p < .05$). In Herat, no idea was presented in the non-AI mediation setting. The increase in idea was not significant in Kandahar. The issue slightly increased in Herat ($p = .224$), significantly increased in Mazare-sharif ($p = .037$), and slightly increased in Jalalabad. However, it slightly decreased in Kabul and Kandahar. Pros increased slightly in Kabul, significantly in Herat, Mazare-sharif, Kandahar, and Jalalabad ($p < .05$). Cons significantly increased in Kabul, Herat, and Mazare-sharif ($p < .05$), and slightly increased in Kandahar and Jalalabad. These findings further emphasize the AI facilitation on improved structured discussions implying that AI is helping participants structure their discussions effectively. This structured approach can contribute to more organized and coherent conversations, making it easier to track the development of arguments, identify key issues and evaluate different perspectives [41], [43], [45].

5. Discussion and Conclusion

Our study yielded several significant findings that shed light on the impact of AI-mediated discussions on participant engagement and opinion expression. Firstly, the observed increase in the number of posts per participant with AI mediation signifies the positive impact on participant engagement, demonstrating increased civic engagement and community empowerment [46], [47], as anticipated in Hypothesis 1. AI facilitation likely reduced barriers to participation [48], encouraged active involvement, and fostered a more inclusive discussion environment, resulting in a diverse range of perspectives. This is a promising indication of how AI can enhance the quality of participatory platforms and promote democratic engagement [49], thereby enhancing decision-making and conflict mitigation.

Additionally, the data generated by these discussions can serve as a valuable resource for future planning, aiding in the development of tailored initiatives and enhancing local resilience in a challenging environment [37], [38]. Furthermore, this approach has also raised awareness about the importance of participatory planning, creating opportunities for international engagement and support, as well as contributing to data for development efforts.

Furthermore, the rise in classified opinions, specifically in the categories of ideas, pros, and cons, suggests that AI effectively encouraged participants to generate a wider range of ideas and express their viewpoints, as hypothesized in Hypotheses 2 and 3. This shift towards more comprehensive problem-solving discussions [50] signifies a positive trend in engagement. Participants are not only contributing a greater number of ideas but also actively discussing the benefits and drawbacks of these ideas. This is indicative of a more informed and inclusive decision-making process among the city's residents. It fosters a culture of transparency, accountability, and adaptability, all of which contribute to more effective solutions for issues and challenges faced by the community [51]. Moreover, it empowers participants to take ownership of the decision-making process and fosters a sense of collective responsibility for their community's future. Our research builds upon prior findings that explored the impact of AI and human facilitation on discussion outcomes [1]. Extending this investigation to the unique and challenging context of Afghanistan, we conducted our study in five cities with diverse socio-economic characteristics, confirming the validity of AI facilitation's influence on increasing the number of opinions across different cultural and contextual settings [38]. This not only bolsters the credibility of AI facilitation's impact but also highlights its scalability and relevance across diverse settings. Our research, set against a backdrop of complex socio-political dynamics, offers promising insights for participatory planning and decision-making. It signifies a valuable approach to community engagement in regions confronting distinct challenges [37].

While our findings offer valuable insights into the impact of AI-mediated discussions on participant engagement and opinion expression, it's crucial to address the limitations of our study. Factors such as participant demographics, topic specificity, and the design of the AI mediation system may have influenced the results. Future research should delve deeper into these factors to provide a more nuanced understanding of the effects of AI-mediated discussions. Additionally, investigating the long-term effects and sustainability of AI-mediated discussions would be valuable in further exploring the potential of AI in promoting participatory decision-making processes.

In conclusion, our study highlights the positive impact of AI mediation on participant engagement and opinion expression in online discussions. The findings contribute to the growing body of research on AI-facilitated interactions and provide valuable insights for both researchers and practitioners. By fostering a more active and diverse discussion environment, AI mediation has the potential to enhance the quality of participatory platforms and promote more inclusive and democratic decision-making processes. As AI continues to advance, further exploration and refinement of AI-mediated discussions hold promise for creating more effective and engaging digital social forums.

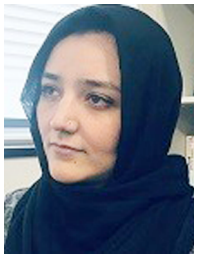
Acknowledgments

This research was supported partially by the JST CREST fund (Grant Number: JPMJCR20D1, Japan) and JSPS KAKENHI (Grant Number: 22K17948, Japan).

References

[1] T. Ito, R. Hadfi, and S. Suzuki, "An agent that facilitates crowd discussion," Group Decision and Negotiation, vol.31, no.3, pp.621–647, 2022.
[2] A. Segura-Tinoco, A. Holgado-Sánchez, I. Cantador, M.E. Cortés-Cediel, and M.P.R. Bolívar, "A conversational agent for argument-driven e-participation," Proc. DG.O 2022: The 23rd Annual International Conference on Digital Government Research, Virtual Event, Republic of Korea, pp.191–205, 2022.
[3] S.N. Williams, "A twenty-first century citizens' POLIS: Introducing a democratic experiment in electronic citizen participation in science and technology decision-making," Public Understanding of Science, vol.19, no.5, pp.528–544, 2010.
[4] T.W. Malone, The future of work: How the new order of business will shape your organization, your management style, and your life, Harvard Business School Press, Boston, 2004.
[5] J. Introne, R. Laubacher, G. Olson, and T. Malone, "The Climate Colab: Large scale model-based collaborative planning," 2011 International Conference on Collaboration Technologies and Systems (CTS), pp.40–47, 2011.
[6] M. Klein, "The MIT deliberatorium: Enabling large-scale deliberation about complex systemic problems," 2011 International Conference on Collaboration Technologies and Systems (CTS), pp.161–161, 2011.
[7] A.X. Zhang, "Building systems to improve online discussion," Proc. Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing, Jersey City, NJ, USA, pp.65–68, 2018.
[8] J.C.R. Licklider, "Man-computer symbiosis," IRE Trans. Human Factors in Electronics, vol.HFE-1, no.1, pp.4–11, 1960.
[9] T.W. Malone and K. Crowston, "The interdisciplinary study of coordination," ACM Comput. Surv., vol.26, no.1, pp.87–119, 1994.
[10] R. Hadfi, J. Haqbeen, S. Sahab, and T. Ito, "Argumentative conversational agents for online discussions," Journal of Systems Science and Systems Engineering, vol.30, pp.450–464, 2021.
[11] R. Vinuesa, H. Azizpour, I. Leite, M. Balaam, V. Dignum, S. Domisch, A. Felländer, S.D. Langhans, M. Tegmark, and F.F. Nerini, "The role of artificial intelligence in achieving the sustainable development goals," Nature Communications, vol.11, no.1, 233, 2020.
[12] E. Mourelatos, M. Tzagarakis, and E. Dimara, "A review of online crowdsourcing platforms," South-Eastern Europe Journal of Economics, vol.14, no.1, pp.59–73, 2016.
[13] J. Howe, "The rise of crowdsourcing," Wired Magazine, vol.14, no.6, pp.176–183, 2006.
[14] M. Hossain and I. Kauranen, "Crowdsourcing: A comprehensive literature review," Strategic Outsourcing: An International Journal, vol.8, no.1, pp.2–22, 2015.
[15] S. Suran, V. Pattanaik, and D. Draheim, "Frameworks for collective intelligence: A systematic literature review," ACM Comput. Surv., vol.53, no.1, Article No.14, 2020.
[16] T.W. Malone and M. Klein, "Harnessing collective intelligence to address global climate change," Innovations: Technology, Governance,

Globalization, vol.2, no.3, pp.15–26, 2007.
[17] M. Klein, "Achieving collective intelligence via large-scale on-line argumentation," Second International Conference on Internet and Web Applications and Services (ICIW'07), p.58, 2007.
[18] L. Iandoli, M. Klein, and G. Zollo, "Can we exploit collective intelligence for collaborative deliberation? The case of the climate change collaboratorium," MIT Sloan Research Paper no.4675-08, 2007.
[19] T. Ito, Y. Imi, T. Ito, and E. Hideshima, "Collagree: A faciliator-mediated large-scale consensus support system," Collective Intelligence, 2014.
[20] A. Sengoku, T. Ito, K. Takahashi, S. Shiramatsu, T. Ito, E. Hideshima, and K. Fujita, "Discussion tree for managing large-scale internet-based discussions," Collective Intelligence, 2016.
[21] K. Takahashi, T. Ito, T. Ito, E. Hideshima, S. Shiramatsu, A. Sengoku, and K. Fujita, "Incentive mechanism based on quality of opinion for large-scale discussion support," Collective Intelligence, 2016.
[22] A. Sengoku, T. Ito, K. Fujita, S. Shiramatsu, T. Ito, E. Hideshima, and K. Fujita, "Towards intelligent crowd decision support: A preliminary result on large-scale discussion support based on the discussion tree," International Conference on Crowd Science and Engineering (ICCSE2016), pp.27–30, 2016.
[23] T. Ito, Y. Imi, M. Sato, T. Ito, and E. Hideshima, "Incentive mechanism for managing large-scale internet-based discussions on COLLAGREE," Collective Intelligence, 2015.
[24] T. Nishida, T. Ito, T. Ito, E. Hideshima, S. Fukamachi, A. Sengoku, and Y. Sugiyama, "Core time mechanism for managing large-scale internet-based discussions on COLLAGREE," 2017 IEEE International Conference on Agents (ICA), pp.46–49, IEEE, 2017.
[25] T. Ito, T. Otsuka, S. Kawase, A. Sengoku, S. Shiramatsu, T. Ito, E. Hideshima, T. Matsuo, T. Oishi, R. Fujita, N. Fukuta, and K. Fujita, "Experimental results on large-scale cyber-physical hybrid discussion support," International Journal of Crowd Science, vol.1, no.1, pp.26–38, 2017.
[26] T. Ito, T. Otsuka, S. Kawase, A. Sengoku, S. Shiramatsu, T. Matsuo, T. Oishi, R. Fujita, N. Fukuta, and K. Fujita, "Preliminary results on a large-scale cyber-physical hybrid discussion support experiment," 2016 11th International Conference on Knowledge, Information and Creativity Support Systems (KICSS), pp.1–6, 2016.
[27] Y. Imi, T. Ito, T. Ito, and E. Hideshima, "A large-scale consensus support system called COLLAGREE based on online facilitation functions—A real-world application for Nagoya next generation total city planning," Information Processing Society of Japan Journal, vol.56, no.10, pp.1996–2010, 2015 (in Japanese).
[28] S. Kawase, T. Ito, T. Otsuka, A. Sengoku, S. Shiramatsu, T. Matsuo, T. Oishi, R. Fujita, N. Fukuta, and K. Fujita, "Cyber-physical hybrid environment using a largescale discussion system enhances audiences' participation and satisfaction in the panel discussion," IEICE Trans. Inf. & Syst., vol.E101-D, no.4, pp.847–855, 2018.
[29] C. Yang, W. Gu, T. Ito, and X. Yang, "Machine learning-based consensus decision-making support for crowd-scale deliberation," Applied Intelligence, vol.51, no.7, pp.4762–4773, 2021.
[30] W. Gu, A. Moustafa, T. Ito, M. Zhang, and C. Yang, "A case-based reasoning approach for supporting facilitation in online discussions," Group Decision and Negotiation, vol.30, no.3, pp.719–742, 2021.
[31] T. Ito, D. Shibata, S. Suzuki, N. Yamaguchi, T. Nishida, K. Hiraishi, and K. Yoshino, "Agent that facilitates crowd discussion," Collective Intelligence, 2019.
[32] J. Haqbeen, S. Sahab, T. Ito, and P. Rizzi, "Using decision support system to enable crowd identify neighborhood issues and its solutions for policy makers: An online experiment at Kabul municipal level," Sustainability, vol.13, no.10, 5453, 2021.
[33] J. Haqbeen, S. Sahab, and T. Ito, "How did discourse shift among Afghan citizens during the fall of republic: Early insights using conversational AI platform," Proc. DG.O 2022: The 23rd Annual International Conference on Digital Government Research, Virtual Event, Republic of Korea, pp.480–482, 2022.
[34] J. Haqbeen, T. Ito, R. Hadfi, T. Nishida, Z. Sahab, S. Sahab, S. Roghmal, and R. Amiryar, "Promoting discussion with AI-based facilitation: Urban dialogue with Kabul city," Collective Intelligence Conference, 2020.
[35] J. Haqbeen, T. Ito, S. Sahab, T. Sato, S. Okuhara, and M. Hofiani, "Insights from a large-scale discussion on COVID-19 in collective intelligence," 2020 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT), pp.546–553, 2020.
[36] G. Porte, "Who needs replication?," CALICO Journal, vol.30, no.1, pp.10–15, 2013.
[37] S. Hall, "A study of poverty, food security and resilience in Afghan cities," For DRC and PIN, 2014.
[38] GoIRA (Government of Islamic Republic of Afghanistan), "State of Afghan cities 2015: Volume One," United Nations Human Settlements Programme, Kabul, 2015.
[39] GoIRA (Government of Islamic Republic of Afghanistan), "State of Afghan cities 2015: Volume Two," United Nations Human Settlements Programme, Kabul, 2015.
[40] W. Kunz and H.W. Rittel, "Issues as elements of information systems," Institute of Urban and Regional Development, University of California, Berkeley, California, 1970.
[41] W.-H.S. Tsai, Y. Liu, and C.-H. Chuan, "How chatbots' social presence communication enhances consumer engagement: The mediating role of parasocial interaction and dialogue," Journal of Research in Interactive Marketing, vol.15, no.3, pp.460–482, 2021.
[42] M. Hoegl and H.G. Gemuenden, "Teamwork quality and the success of innovative projects: A theoretical concept and empirical evidence," Organization Science, vol.12, no.4, pp.435–449, 2001.
[43] N. Tavanapour, M. Poser, and E.A. Bittner, "Supporting the idea generation process in citizen participation—Toward an interactive system with a conversational agent as facilitator," ECIS, 2019.
[44] S. Kim, J. Eun, C. Oh, B. Suh, and J. Lee, "Bot in the bunch: Facilitating group chat discussion by improving efficiency and participation with a chatbot," Proc. 2020 CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA, pp.1–13, 2020.
[45] J. Bang, S. Kim, J.W. Nam, and D.-G. Yang, "Ethical chatbot design for reducing negative effects of biased data and unethical conversations," 2021 International Conference on Platform Technology and Service (PlatCon), pp.1–5, IEEE, 2021.
[46] M. Anastasiadou, "What is the impact of information systems on democracy promotion and the role in decision-making process," Repositorio Universidade Nova, 2019 (Doctoral dissertation).
[47] H. Jafarkarimi, A. Sim, R. Saadatdoost, and J.M. Hee, "The impact of ICT on reinforcing citizens' role in government decision making," International Journal of Emerging Technology and Advanced Engineering, vol.4, no.1, pp.642–646, 2014.
[48] S. Shahab, B. Bagheri, and R. Potts, "Barriers to employing e-participation in the Iranian planning system," Cities, vol.116, 103281, 2021.
[49] B. Ragi Eis Mendonca and S. De la Llata, "Toward digital democracy, e-planning and e-participation practices: The use and value of ICTs in the digital era," World Congress of Architects, pp.365–375, Springer, 2023.
[50] P.B. Paulus and V.R. Brown, "Toward more creative and innovative group idea generation: A cognitive-social-motivational perspective of brainstorming," Social and Personality Psychology Compass, vol.1, no.1, pp.248–265, 2007.
[51] D. Swanson, L. Bizikova, C. Thrift, and D. Roy, "Governabilities: The nexus of sustainability, accountability and adaptability: Essential tools for successful governance in the 21st century," International Institute for Sustainable Development, 2014.



Sofia Sahab is a program specific assistant professor in Kyoto University, Japan. She previously worked as assistant professor with Nagoya Institute of Technology, Japan, and Kabul University, Afghanistan. In 2017, she received a Ph.D. in urban planning from Nagoya Institute of Technology, Japan. Her current research interests include developing participative online decision support systems for supporting city collaborative planning processes in collective intelligence. She has published research articles in journals, such as, Scientific Reports (Nature), Journal of Simulation and Gaming (SAGE Publications) and Journal of Architecture and Planning (Transections of Architectural Institute of Japan). She is one of the recipients of the Japan Science and Technology Agency AIP program. She is currently member of Japan Society of Artificial Intelligence (JSAI), and Digital Government Research Society (DGO).

Jawad Haqbeen is a program specific assistant professor at Kyoto University, Japan. He received M.S. and Ph.D. in Computer Science from Waseda University and Nagoya Institute of Technology in 2013 and 2022, respectively. His current research interests lie in human-agent interaction, experimental user studies, collective intelligence, and applying artificial intelligence to civic technologies. He is the author/co-author of over 20 conference proceedings articles, and more than 6 journal articles. He received the Excellent Paper Award in KICSS2023, Excellence Paper Award in JSAI2023, Best Presentation Award in KICSS2021, IBM Award of Scientific Excellence in PAAMS2020, Best Paper Award in KICSS2020, and IEEE Nagoya Section Research Presentation Award in 2018. He is a member of Japan Society of Artificial Intelligence (JSAI), and Digital Government Research Society (DGO).

Takayuki Ito is a professor at Kyoto University. He received the B.E., M.E., and D.Eng. from Nagoya Institute of Technology in 1995, 1997, and 2000, respectively. He was JSPS research fellow, an associate professor with JAIST, visiting scholar at USC/ISI, Harvard University and MIT, and professor with Nagoya Institute of Technology, Japan. He was a board member of IFAAMAS, PC-chair of PRIMA09 and AAMAS13, and general-chair of PRIMA14, ICA16, PRIMA20 and local arrangement chair of IJCAI20 international conferences. He was recipient of the JSIA achievement, JSPS prize, JSSST, MEXT, MEXT young scientist, IPSJ Awards and AAMS06 Best Paper Award. He is the author/co-author of more than 213 conference proceedings articles, and more than 62 journal articles. His research interests include artificial intelligence, crowd-based discussion support systems, collective intelligence and multi-agent systems. He is a senior member of ACM, AAAI, JSAI, IEICE, JSST, SICE, JEA, and IPSJ. He is currently principal investigator of JST CREST project.