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BUILDING USER-FRIENDLY FRAMEWORKS TO SUPPORT USABILITY AND LEARNING IN GENERATIVE AI

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Abstract

Generative Artificial Intelligence is revolutionizing user experience (UX) design, creative practice, education, and immersive technology. While its potential extends to text, image, audio, and multimodal systems, issues of usability, accessibility, and successful integration remain. This study suggests a human-centered paradigm for evaluating and building GenAI systems that integrates functionality with user interface and UX principles. Drawing on ideas from creative tools, adaptive virtual reality interfaces, educational scaffolding for non-technical learners, and AI-augmented design processes, the study looks into common barriers including articulation challenges, prompt instability, and explainability gaps. The framework will guide the development of intuitive, ethical, and inclusive GenAI systems via empirical investigations and comparative analysis. The findings seek to help practitioners and learners use GenAI as a collaborative partner, as well as shape future approaches for responsible and user-centered adoption.

INTRODUCTION

Generative AI is transforming creative and immersive technology, yet usability difficulties remain. The articulation barrier is a major difficulty in text-to-image systems, where users struggle to articulate purpose via prompts, frequently resulting to irritation and poor outcomes [1]. Hybrid interfaces, which mix text input with graphical elements like sliders and templates, have shown potential for decreasing cognitive load and enhancing accessibility [1]. Similarly, adaptive user interfaces in virtual reality can improve performance and engagement, cutting task completion time by 18.6%, errors by 47.8%, and satisfaction by 34.9% [3]. These findings highlight the importance of human-centered frameworks in generative AI that incorporate usability, adaptability, and inclusivity to facilitate effective engagement across multiple modalities.

Generative AI systems, particularly text-to-image tools like Midjourney, DALL·E, and Stable Diffusion, revolutionize creative workflows. However, they also present a fundamental usability difficulty known as the articulation barrier. Users frequently struggle to create prompts that effectively reflect their visual intent, resulting in frustration and inefficiency. Hybrid interfaces combining text-based prompts and graphical buttons can reduce cognitive burden and improve prompt exploration. [1]. Adaptive AI-driven interfaces in immersive environments, such as virtual reality, improve performance and user experience: one study with 50 participants reported an 18.6% reduction in task completion time, a 47.8% decrease

in errors, and a 34.9% increase in satisfaction, with physiological data confirming lower stress and higher engagement [2]. These findings underscore the critical need for human-centered frameworks that integrate usability, interface design, and adaptive intelligence across generative AI systems.

Despite its expanding potential in artistic, educational, and professional arenas, Generative AI (GenAI) faces continuing usability issues. One of the most important is the articulation barrier, which occurs when users struggle to articulate effective suggestions that match their aims, frequently resulting in unsatisfying or unexpected results [1]. Furthermore, systems suffer from quick instability, where tiny changes in phrasing can lead to disproportionately different outputs [15]. Furthermore, the lack of explainability in GenAI outputs undermines user trust and transparency, making it difficult for both expert and novice users to grasp how results are produced [16]. Current GenAI interfaces are frequently not designed with non-technical learners in mind, resulting in steep learning curves and reduced accessibility.

Existing research has provided useful insights into specific uses of GenAI technologies, but it remains dispersed across disciplines. For example, [16] focuses on interface problems in text-to-image systems [17] show the advantages of adaptive UIs in virtual reality environments. Similarly, [15] emphasize the importance of broad language models in education while noting that their integration remains unexplored for non-technical learners. However, no cohesive framework exists to combine these strands—usability, UI/UX design, and instructional scaffolding across several GenAI modalities (text, image, audio, and multimodal). Furthermore, while much of the literature focuses on system performance and output quality, fewer studies look into how GenAI might serve as a collaborative partner in human-centered workflows, especially in situations where inclusivity, transparency, and adaptability are essential.

To solve these issues, this study proposes four goals. First, it presents a taxonomy and paradigm for analyzing GenAI systems from a human-centered standpoint, which includes text, image, audio, and multimodal applications. Second, it intends to explore interaction patterns and impediments, such as articulation difficulties, explainability gaps, and cognitive load, in user engagement with GenAI. Third, the project investigates educational integration by developing scaffolding approaches and incremental prompting strategies to empower non-technical UX learners, relying on work in AI-assisted education [13]. Finally, it aims to provide practical design guidelines for creating inclusive, ethical, and adaptive GenAI systems that not only enhance usability but also promote responsible adoption. In doing so, this research contributes to bridging the gap between the technical capabilities of GenAI and the human-centered principles of HCI and UX design.

Literature Review:

Generative Artificial Intelligence (GenAI) has rapidly expanded across domains such as creative practice, education, and immersive technologies, offering unprecedented opportunities but also raising new challenges for human-computer interaction (HCI). Researchers have highlighted the importance of evaluating GenAI not only by the quality of its outputs but also by its usability, inclusivity, and potential to act as a collaborative partner in design and learning contexts. This section reviews recent literature across four key themes: usability challenges, adaptive interfaces, educational integration, and explainability in GenAI.

i. In this paper the author focused on Parallel to usability concerns in text-based and creative applications, [2] investigated adaptive user interfaces in virtual reality (VR), where interface elements adjusted in real time to user interaction and context. Their study with 50 participants reported reduced task completion times, fewer errors, and higher satisfaction, with physiological data confirming lower stress and greater engagement. These findings provide empirical support for the role of AI-driven adaptivity in enhancing accessibility and usability in complex environments like VR.

ii. In their study, [1] focused on the articulation barrier as a critical challenge in GenAI, highlighting how non-expert users struggle to translate intentions into effective prompts. Similarly, [9] emphasized that ineffective prompting arises from knowledge gaps, unstable AI outputs, and unclear mental models. Together, these works identify usability as a major

bottleneck, pointing to the need for hybrid or adaptive interaction designs.

iii. The author [3] investigated the use of large language models (LLMs) in education, recognizing their potential for customization and accessibility but also highlighting problems of over-reliance and ethical considerations. Tools like GitHub Copilot can scaffold learning for non-technical learners by prompting them incrementally, lowering the entry barrier to computational innovation. However, additional study is required to ensure equal incorporation into curriculum.

iv. In this paper the author focuses Human-centered AI talks emphasize the importance of explainability. [4] underlines that without defined processes for comprehending AI outputs, trust and transparency in generative systems are constrained. Explainability in HCI and UX design influences not only user confidence, but also adoption in professional and educational settings. Ethical design techniques must consequently include explainability as a basic requirement rather than an afterthought.

v. The author discusses the articulation barrier in text-to-image systems, where users struggle to convey their visual intents through prompts, leading to dissatisfaction and misalignment. [15] similarly identify quick instability and mental model gaps as major usability challenges. These studies highlight the need for interface designs that go beyond basic prompt-based interaction, delivering more natural, guided support.

vi. In [16], the authors demonstrate that AI-driven adaptive UIs in VR settings considerably improve task performance, minimize errors, and increase user happiness, with physiological evidence indicating lower stress and greater engagement. Furthermore, [17] show that interfaces that dynamically simplify features according on user competence reduce work completion times by up to 35% and reduce cognitive burden. Together, they highlight the importance of adaptability in making complicated systems more useable and accessible.

vii. In this study, the author[7] investigates structured multimodal interfaces in GenAI technologies, notably the ACAI advertising tool. It organizes the prompt interface with branding, audience, and inspiration panels to assist beginner users in more effectively communicating creative goals, eliminating ambiguity and improving alignment. [12] investigates multimodal GenAI interactions (text, speech, and video), highlighting issues such as privacy, context retention, and cross-platform adaptability. They envision future possibilities such as emotionally adaptable and predictive interfaces.

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ix. In this author [11] discussed the opportunities and risks of LLMs in education, highlighting the importance of structured integration. [9] described a "AI-Lab" intervention in computer science, demonstrating that directed scaffolding enhances students' comfort and reflective use of GenAI. Similarly, [21] found that proactive GenAI agents using scaffolding tactics improved comprehension of visual learning analytics more than passive agents.

x. The author assesses how UX experts use GenAI in industry, revealing ad-hoc usage, lack of organizational policies, and unsupported team-based solutions. Practitioners often employ GenAI for text-based activities, but struggle with design-related applications like as prototyping and wireframing. [10] They advocate for more training and institutional support to properly use GenAI in UX workflows.

Research Methodology:

This study takes a mixed-methods approach, including comparative and empirical components. First, we compare existing GenAI tools, such as ChatGPT, DALL·E, Midjourney, and GitHub Copilot. Second, we use Google Colab to develop and implement empirical user studies that include bespoke datasets and controlled experiments. The methodology, which builds on previous research on articulation barriers (Mugunthan, 2023) and adaptable UI design, focuses on evaluating usability,

explainability, and learning scaffolds across many modalities.

Data Collection

In the data collection phase, we utilized the Midjourney dataset, which was gathered from user–AI interactions on the Discord platform. Users submitted natural language prompts through the /imagine command, and the system generated corresponding image outputs. The dataset captures both inputs and outputs, including four modules: prompts – the text instructions provided by users, (ii) generated images – links to the AI-produced outputs, (iii) metadata – timestamps, anonymized user identifiers, and contextual details, and (iv) generation settings – system parameters such as aspect ratio, quality, and model version. Data was collected using automated scripts that scraped and organized this information in a structured format. To ensure reliability and ethical compliance, duplicate records were removed, user identities were anonymized, and harmful or inappropriate content was filtered. This dataset offers a rich foundation for examining usability patterns, articulation barriers, and prompt design strategies, which are central to evaluating the role of Generative AI in human-centered UI/UX design.

Conversion of time stamp to date time:

The code first converts the timestamp column into a datetime format for accurate time analysis. It then extracts features such as year, month, day, hour, and day of the week. These derived features allow researchers to track user activity patterns over time. Such temporal insights help in understanding when and how users interact with Generative AI systems.

Attachment Feature Extraction

This code defines a function to analyze the attachments in each record of the dataset. It first checks if a record contains attachments, then counts the total number of attachments and extracts details of the first one, such as file size, width, height, and content type. These extracted features are added as new columns in the dataset, allowing deeper analysis of how attachments (like images, files, or media) contribute to user interactions. This step enriches the dataset by linking content characteristics with user behavior.

Author Feature Extraction

This code defines a function to extract information from the author column of the dataset. It retrieves key details such as the author's unique ID and username, which are then stored as new columns for easier analysis. By structuring author-related data, researchers can track user contributions, identify interaction patterns, and analyze behaviors at the individual level. This step is crucial for linking user identity with their generated content and activities.

Mentions Feature Extraction

This code extracts structured information from the mentions and mention roles columns of the dataset. It calculates the number of users mentions and the number of roles mentioned within each record, storing them as new dataset columns. These features help in analyzing how frequently users and roles are referenced in interactions, providing insights into communication patterns, collaboration dynamics, and the level of engagement within the platform.

Categorical Feature Encoding

This code processes categorical columns such as channel_id, first_attachment_content_type, and author_username using one-hot encoding. Each unique category is transformed into a separate binary column (0 or 1), making the dataset machine-learning ready. This step ensures that categorical attributes, which are non-numeric by nature, can be effectively used in predictive models and statistical analyses, enhancing the dataset's analytical value.

Missing Values Identification

The analysis of missing values revealed that several columns in the dataset contain incomplete data. For instance, edited timestamp (3527 missing) and application_id (3526 missing) have large gaps, while features like first_attachment_size, first_attachment_width, and first_attachment_height each have 153 missing values, often due to records without attachments. Similarly, message_reference and webhook_id also show missing entries. Identifying these gaps is crucial for the data preprocessing phase, as it guides decisions on

whether to impute, drop, or engineer alternatives to maintain the dataset's integrity and reliability for further analysis.

Handling Missing Values

This step manages missing data by applying two strategies: dropping and imputation. Columns with more than 50% missing values edited_timestamp, application_id, webhook_id) are dropped, as their incompleteness reduces reliability. For the remaining missing entries, numerical columns are imputed with their mean values, ensuring consistent statistical representation, while categorical columns (if any remain after encoding) are filled with their mode values. Finally, the dataset is rechecked to confirm no missing values remain. This process improves data quality, prevents biases, and ensures readiness for subsequent analysis and modeling.

Results & Discussion:

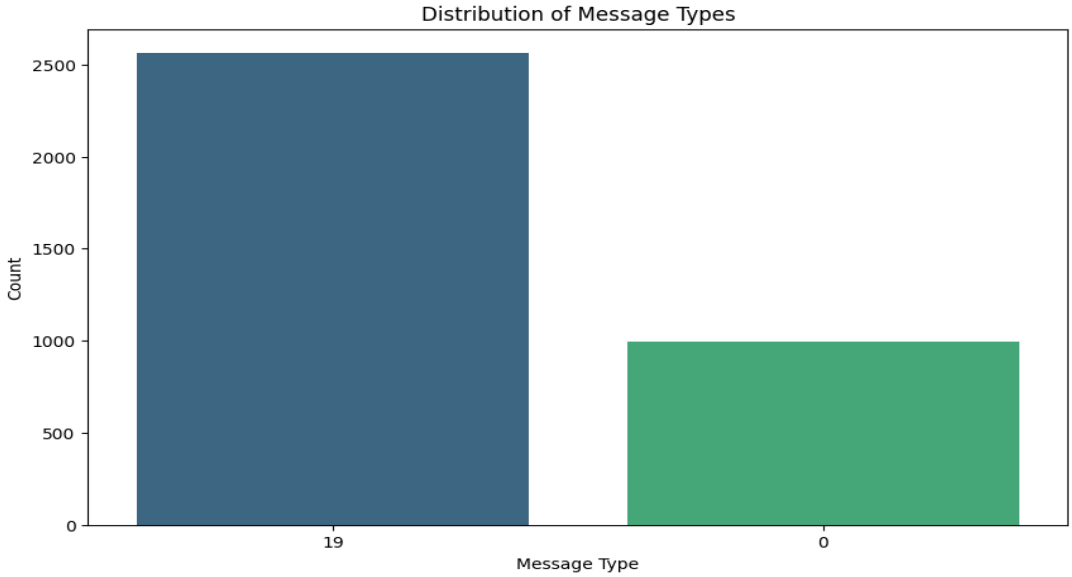

Fig:2

This bar chart shows the distribution of message types across the dataset shown in Fig.2 The majority of entries fall into one dominant category, while the second type appears significantly less frequently. This imbalance suggests that users rely much more heavily on one message format, which may influence both system design and downstream analysis**.**

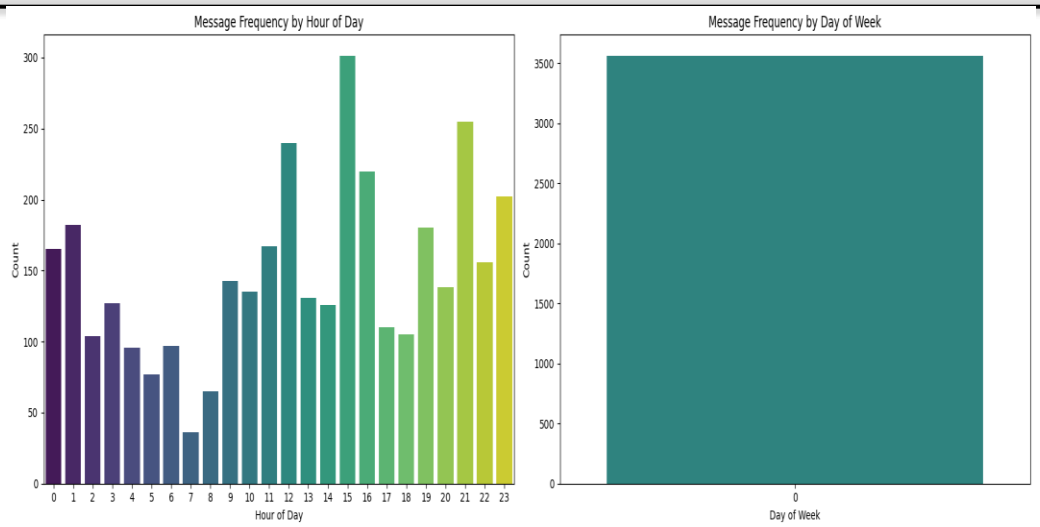

Fig.3

The left-hand bar plot shows how message activity fluctuates throughout the day. Peaks can be observed during certain hours, indicating specific periods of higher user engagement. These temporal patterns provide insight into user behavior and system load, which may help optimize resource allocation or interface design.

The right-hand bar plot illustrates the distribution of messages across different days. Activity appears heavily concentrated on one particular day, with minimal usage during the rest of the week. This uneven distribution could be linked to task scheduling, event-driven use, or external constraints affecting user interaction has shown in Fig.3.

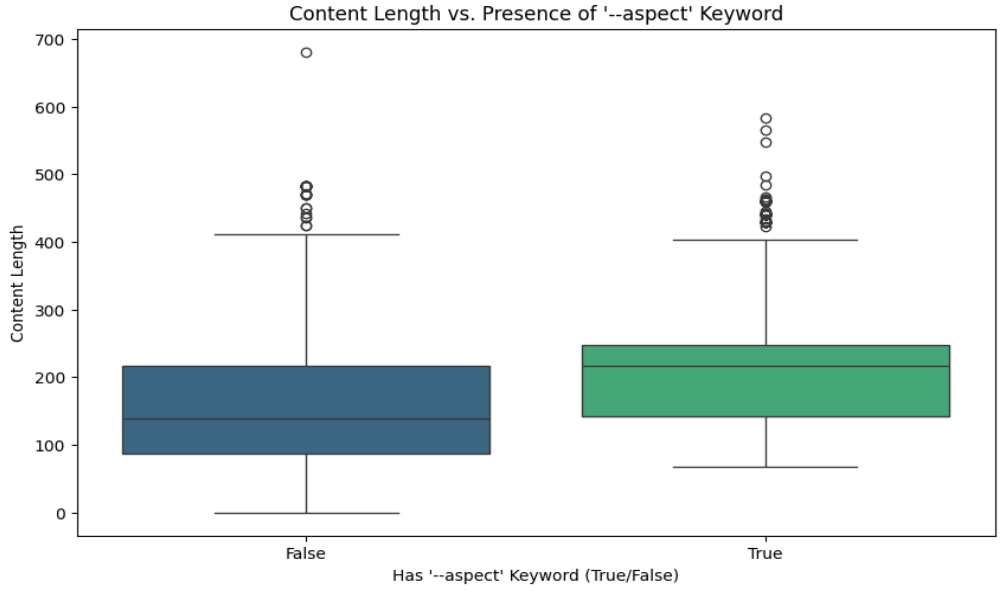

Fig.4

The boxplot compares content length for messages with and without the "-aspect" keyword. Messages containing this keyword tend to have slightly higher variability in length, with more outliers, but the median length remains comparable to those without it. This indicates that while the keyword may sometimes lead to more detailed prompts shown in Fig.4 it does not consistently produce longer text.

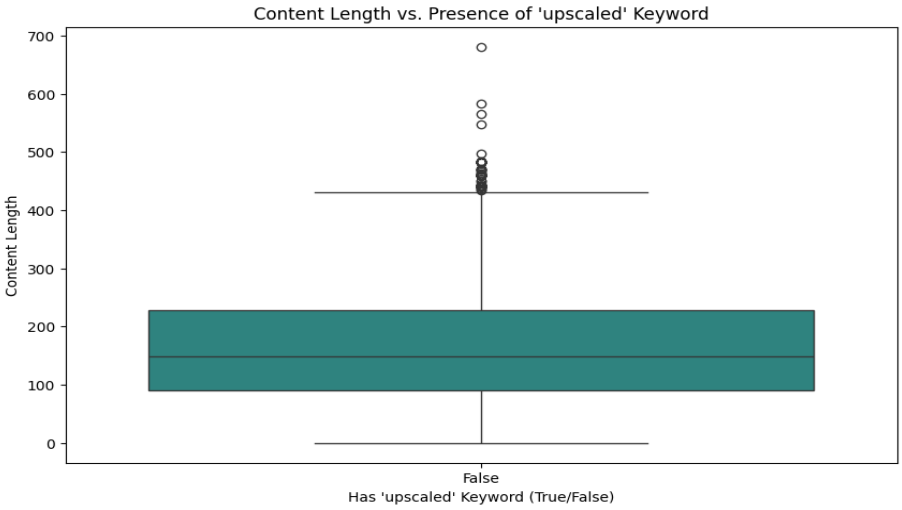

Fig.5

The boxplot compares messages that include the term "upscaled" with those that do not. Shown in Fig.5 The distribution remains relatively consistent across both categories, suggesting that the use of this keyword does not significantly affect message length. This implies that "upscaled" is likely used in short, directive prompts rather than extended descriptions.

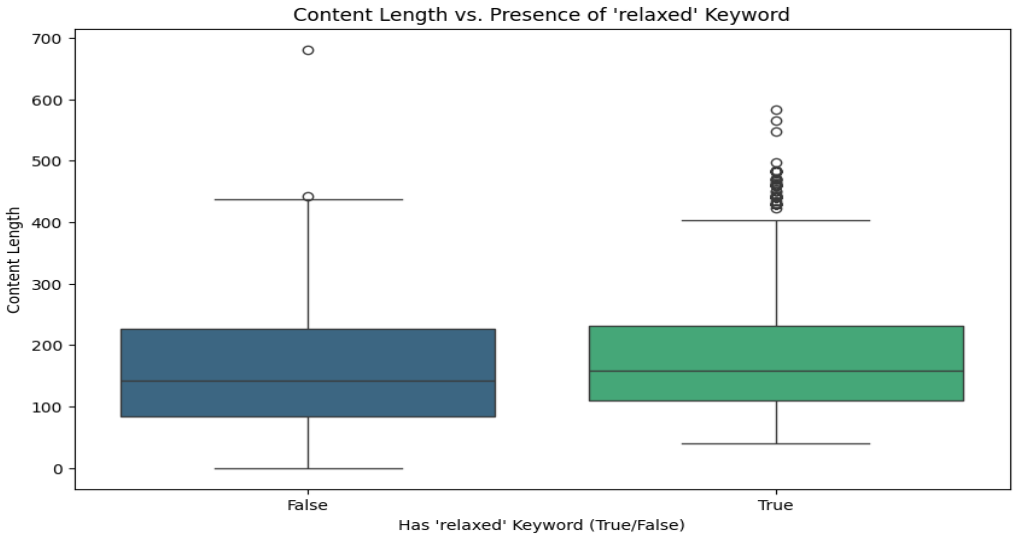

Fig.6

This visualization highlights the difference in content length for prompts containing the word "relaxed" versus those that do not. Shown in Fig.6 The overall distributions are similar, but prompts with the keyword display a wider spread and more extreme outliers. This suggests that when users include this keyword, they may experiment with more varied or detailed phrasing.

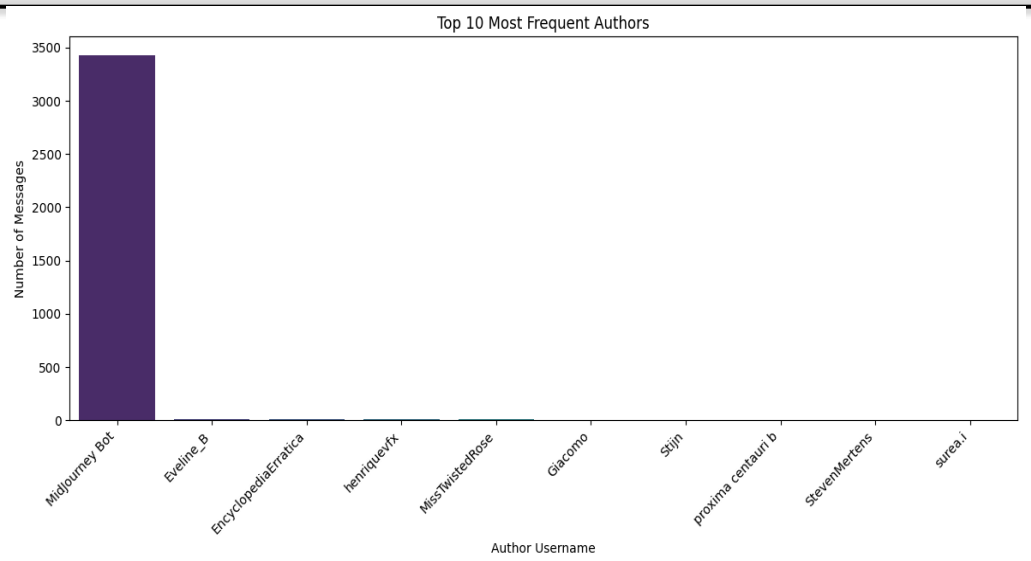

Fig.7

The final bar chart ranks the top 10 contributors by message frequency shown in Fig 7. One author stands out with a disproportionately high number of messages compared to others, highlighting uneven participation. This concentration of activity among a small number of users may influence dataset characteristics and should be considered when interpreting overall trends.

Conclusion:

Generative AI is no longer just a technical novelty—it is becoming an essential part of how people design, learn, and create. However, alongside its potential, it brings challenges that demand careful attention. One of the most critical is the articulation barrier: users often find it difficult to translate creative ideas into the structured prompts that AI requires, which can lead to frustration, inefficiency, and missed opportunities. By exploring hybrid approaches that combine natural language with visual or interactive elements, we show that these barriers can be lowered, enabling a more natural and intuitive design process. Our findings also highlight the importance of adaptive interfaces in immersive environments. In contexts such as virtual reality, AI-driven user interfaces not only improve accuracy and efficiency but also create richer, less stressful, and more engaging experiences. These results reinforce the idea that usability should be seen as central to the success of AI systems, rather than an afterthought.

Beyond evaluating existing tools, this research contributes a human-centered framework for understanding and assessing generative AI systems across text, image, audio, and multimodal applications. It emphasizes inclusivity, transparency, and educational scaffolding as core design principles. We further provide an open dataset of prompts, outputs, and interaction logs to help researchers and educators benchmark AI usability and simulate real-world challenges.

Taken together, these contributions move the field toward more usable, adaptive, and equitable AI systems. The work not only advances academic knowledge but also offers practical guidance for educators, designers, and developers who are striving to create AI experiences that empower rather than overwhelm. As generative AI becomes deeply integrated into everyday workflows, the goal should not just be producing more powerful systems, but systems that truly understand, support, and collaborate with their human users.

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