Generating Visual Aids to Help Students Understand Graphic Design with EKPHRASIS

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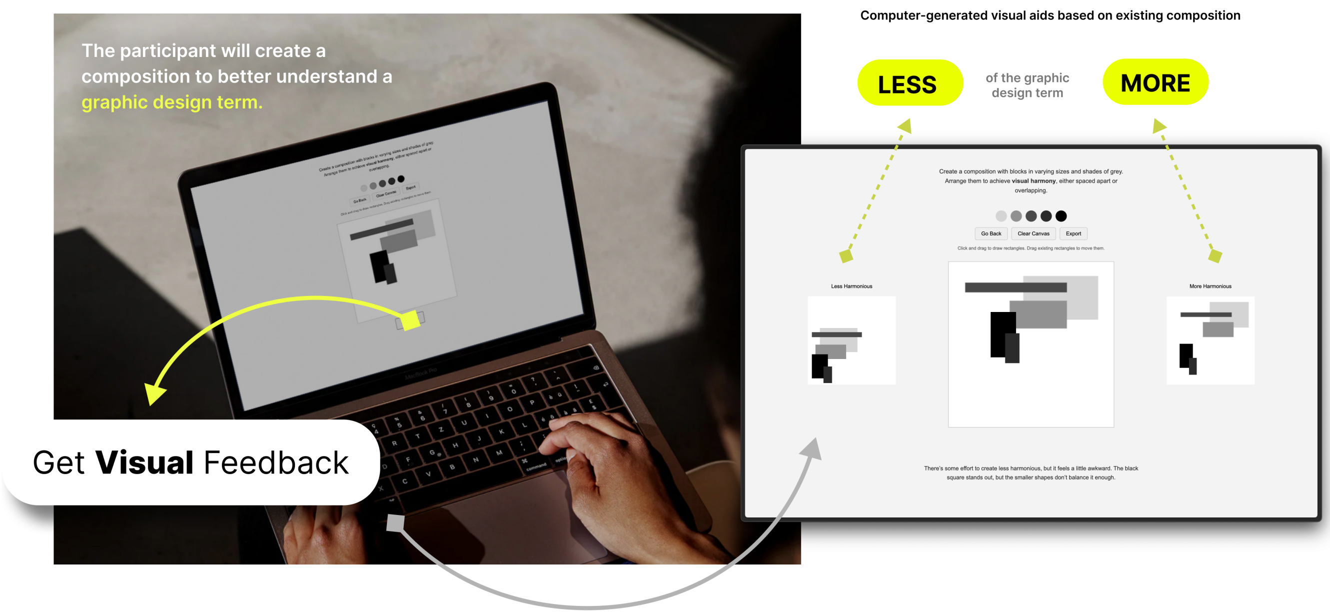

Figure 1: Ekphrasis is an interactive educational system designed for graphic design students to enhance their understanding of key design prompts, such as "visual harmony." Students begin by creating a composition on a digital canvas, after which the system provides concrete, computer-generated visual aids. These aids include "less effective" and "more effective" examples based on the student's composition, offering a comparative perspective. Through this iterative process, students refine their designs while associating graphic design vocabulary with visual representation.

Abstract

Graphic design relies on complex language that creates significant barriers in design education, especially for students from non-design backgrounds or those with language barriers. Our interview with 11 graphic design educators and professional designers confirmed that this specialized language—characterized by jargon, ambiguous terminology, and vague words—operates within insular communities, making it challenging for learners to decode and internalize its meaning. To address this challenge, we developed Ekphrasis, an interactive educational system powered by a machine-learning model that provides real-time and actionable

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visual aids to support students' subjective understanding of design language. Preliminary user testing with novice participants suggests that EKPHRASIS enhances intuitive, multi-modal learning and teaching in graphic design. Through EKPHRASIS, we explore the potential for AI technologies to democratize design pedagogy with real-time, context-aware multi-modal learning support.

CCS Concepts

• **Applied computing → Education, Computer-assisted instruction**.

Keywords

Design Education, Graphic Design, Visual Aids

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1 Introduction

Graphic Design is a crucial domain in Human-Computer Interaction. Effective graphic design enhances the way people interact with computers and digital technologies, improving information architecture [12, 15], reducing cognitive load [18, 22, 48], and fostering intuitive interactions [2].

Graphic design often employs a complex language that may cause miscommunication. Individuals may encounter challenges comprehending terms and phrases such as "make it more sophisticated," "it doesn't feel on-brand," or "it needs more visual hierarchy" [10]. Recognizing the significance and subtleties of these phrases supports various aspects of design work, including communication, creativity, and collaboration [8]. However, there are two types of barriers to learning design language. First, design language is inherently multi-modal and tacitly learned; the ability to associate visuals and design actions with words typically develops through continuous practices. Second, access to communities, such as design schools, professional workshops, or online platforms with inspiring case studies, is essential for receiving feedback and learning collaboratively to master design language. These barriers are particularly challenging because they are developed within insular communities and rely heavily on tacit knowledge and practice, making them difficult to access and learn. This is especially significant for individuals with language barriers, who are already disadvantaged.

Existing methods for teaching graphic design focus on verbal and written critiques, which often fail to provide the context or clarity needed for students to understand their next steps or internalize the tacit knowledge effectively. These challenges are compounded by the prevalence of complex vocabulary in professional design discourse, making it difficult for learners to connect language with visual execution.

To address these issues, our study investigates the following research questions:

RQ1: What kind of linguistic challenges are impacting communication and learning in graphic design education?

RQ2: How can an interactive system assist students understand design language terminology in the context of graphic design?

To answer RQ1, we interviewed 11 educators and designers in formative study to understand the challenges they face in communicating complex design vocabulary effectively. We then leveraged insights from the formative study to develop EKPHRASIS, a machine learning-powered interactive system that offers real-time visual feedback for obscure design prompts, and conducted preliminary user testing to investigate RQ2. By integrating visual references, EKPHRASIS aims to enhance students' comprehension of graphic design language and support inclusive design practices.

2 RELATED WORK

Artificial intelligence (AI) has been increasingly integrated into education, offering new opportunities to enhance learning experiences and teaching methodologies. Research indicates that AI-driven educational tools can provide personalized learning pathways [45], enhance visual comprehension [27], and reduce cognitive load in specialized knowledge domains [20].

Recent advancements in AI-powered tools provide valuable insights into enhancing creative and educational practices in various design and artistic domains. These tools emphasize the integration of multi-modal systems to provide feedback for complex skill learning. Duan et al. utilized GPT-4-based feedback to effectively identify subtle errors, enhanced textual elements, and addressed the UI semantics [14]. Wei et al. explored how audio and visual feedback systems could support learning in musical conducting [49]. Nandy et al. explored how the semantic richness of prompts influences creative 3D modeling output [30].

Researchers have begun to study graphic design as a critical field in HCI. Son et al. investigated tacit knowledge in graphic design as a subject matter and proposed specific elements, actions, and purposes of tacit knowledge instances in graphic design with their characteristics, finally providing guidelines for applying tacit knowledge effectively and delivering personalized feedback in practice [43]. Despite its significance, graphic design remains an intricate field with limited AI-powered, multi-modal learning tools to support its education and practice.

As a visually driven discipline, graphic design will greatly benefit from the integration of visual aids to enhance learning and comprehension. Visual aids have been extensively studied across other various fields, demonstrating their effectiveness in enhancing learning outcomes. Katz et al.'s study highlights the effectiveness of pictorial aids in improving patients' medication recall, comprehension, and adherence [24]. Mbanda et al.'s study demonstrates the significant impact of visual aids, like pictograms and videos, in improving health literacy and medication adherence among low-literacy populations [28]. Oz et al.'s study reveals that integrating visual materials into anatomy education facilitates students' comprehension of medical terminologies [37]. King et al.'s research in South African schools shows that visual aids facilitate understanding of complex life science concepts, overcoming language barriers [25]. Patescan et al.'s study in visual aids in language education is shown to effectively clarify complex information, sustain engagement, and improve retention [39].

Participant	Description
F1	Graphic designer and art director with 20 years of experience in branding and design, university lecturer
F2	Graphic designer, multi-media artist, product designer with 15+ years of experience, university lecturer
F3	Graphic designer, renowned design methodology researcher with 40 years of experience, design consultant, university lecturer
F4	Graphic designer, multi-media artist
F5	Associate professor, interaction designer, HCI researcher, digital media artist
F6	Graphic designer, brand consultant, design methodology researcher, writer
F7	Associate professor, architect, writer, machine-learning researcher
F8	Graphic designer, university lecturer
F9	Professor, cognitive scientist with 20+ years of experience in education research and a deep understanding of graphic design
F10	Visual artist, HCI researcher
F11	Graphic design educator, industrial designer
P1	Mechanical engineer, researcher in physics, no prior experience with graphic design
P2	Musician, with a strong interest in painting

Table 1: Data on participants in our formative study (F1-F11) and preliminary testing (P1-P2).

These studies motivated the development of EKPHRASIS, highlighting the potential of leveraging AI and visual aids in assisting graphic design education. Unlike existing approaches that rely primarily on (AI generated) textual explanations or verbal critique, EKPHRASIS introduces a novel method by using visual aids as a medium to translate abstract design terminology into concrete, perceivable forms. This approach has the potential to shift the focus from passive language interpretation to an active, visual learning process, offering a possible way to make complex design concepts more accessible.

3 Formative Study: Understanding Challenges in Design Communication

To build a thorough understanding of the overlooked challenges in design communication, we conducted semi-structured, one-on-one interviews with 11 experts (Table 1) across diverse academic and professional domains, including architecture, graphic design, cognitive science, and education. Out of the 11 interviewees, including educators, designers, and researchers, 7 were non-native English speakers, and all 11 were multilingual. They shared their unique experiences and perspectives on the intricate dynamics of design communication.

We identified 3 key linguistic patterns in graphic design discourse, providing key insights into the complexities of language used in graphic design discourse, shaping the subsequent focus of this study on developing solutions to facilitate more accessible communication in graphic design education.

3.1 Method: Reflexive Thematic Analysis

To analyze the qualitative data collected during the formative study, we employed Reflexive Thematic Analysis [3, 4]. This approach emphasizes the interpretive role of researchers in identifying and developing themes from the data.

We adopted a flexible, note-based method to capture key observations and patterns from interview transcripts. This iterative process included multiple rounds of reviewing the data, during which we systematically identified recurring concepts and themes that reflected participants' experiences and perspectives.

This method enabled us to understand the challenges in graphic design communication and generate actionable insights that informed the development of EKPHRASIS.

Key phases of our analysis included:

1. Familiarization with the data: Repeatedly reading the transcripts and noting significant ideas.

2. Theme development: Extracting meaning-based patterns that highlighted challenges in design communication and user engagement with visual feedback tools.

3. Refinement: Reviewing and refining themes to ensure they accurately captured the nuances of the data and aligned with our research objectives.

3.2 Results: 3 Kinds of Challenging Graphic Design Linguistic Patterns

Graphic design is not an intuitive profession; it requires a thorough understanding of a specialized language [21]. The educational forms of communication naturally transition into professional discourse, reflecting the collaborative and project-oriented nature of these settings [6]. Students regularly interact with mentors and peers, exchanging ideas and feedback. For instance, during a critique session, an instructor might remark: "I think the spatial hierarchy in this layout lacks clarity and could lead to a diminished user experience." Having the ability to reflexively associate terms like, "spatial hierarchy", "clarity", and "diminished," with specific, multi-modal concepts is integral to participating in professional graphic design discourse. However, the process of mastering terms like these can be daunting and time-consuming, particularly for students. From the formative study, we categorize challenging terms in graphic design language based on three main characteristics: jargon, ambiguity, and underspecification.

3.2.1 Jargon. The graphic design profession has a well-established culture of using jargon, e.g. "kerning" and "lorem ipsum" in typesetting, "ascender" and "cap-height" in font design, or "bleed" in print matters. 5 out of 11 interviewees mentioned the use of jargon, and F12 and F5 both remarked that the newer students are disadvantaged by this. F1 mentioned that fewer graphic design students choose type design as a career due to its unmeasurable usage of typography jargon.

Jargon possesses an inaccessible quality. Metaphors are often embedded in jargon [16], shaping cognitive processes [26] and underscoring the importance of understanding semantics for enhancing creativity within the design community [13]. However, metaphorical jargon could encapsulate complex ideas and hinder creative thinking. F4 mentioned: "For non-native speakers, metaphorical jargon introduces dual layers of confusion, as it employs unfamiliar words, often tied to specific cultural and historical contexts, to explain equally unfamiliar concepts." For instance, the word "bleed" in printing derives from Old English "blēdan," meaning "to shed blood," and was later applied to signify overflow or spillage. Today, "bleed" refers to the practice of extending images or colors beyond the trim edge to prevent white borders caused by cutting misalignments. [9]. "Only a very few designers know the backstory and teach in this relatable way," said F4.

3.2.2 Ambiguity. Ambiguity is a prevalent phenomenon in language, meaning "having different possible meanings; open to more than one interpretation [31]." Efficient communication systems inherently incorporate ambiguity when context provides sufficient information to clarify meaning [40]. In conversation, an interpreter can discern the intended meaning of a word when the context is adequately informative. Ambiguity can serve as a source of inspiration for experienced artists and designers [19], adding depth and richness to their work [46].

Yet in graphic design education, the context of communication often extends beyond verbal interaction to include visual elements, requiring a translation process between semantics and visuals. In such cases, ambiguous terminologies may sound obscure to students, providing limited informational context and complicating their understanding. F1 noted that by midterm, novice students could engage in fluent conversations using abstract terms but still faced challenges in understanding the instructor's advice.

6 interviewees (F1, F2, F3, F4, F8, F11) noted that ambiguous terminologies are most frequently associated with fundamental design principles during formative studies and desk research [41]. For example, the principle "contrast" encompasses differences in size, color, value, shape, and various other elements used to highlight a specific element in a design [44]. Ambiguity may arise if the specific aspect of contrast isn't clarified. F5 gave an example: "When a person says, 'Increase contrast in this design,' the expected action is unclear—whether it involves adjusting brightness, adding color differentiation, or emphasizing differences in scale."

3.2.3 Vagueness. Vagueness is another common phenomenon in language, defined as "not precise or exact in meaning" [36]. Some terms are ambiguous because they have multiple meanings, while others are vague because they lack specificity [35]. F6 and F10 remarked that certain terms can be both ambiguous (having multiple possible meanings) and vague (without a precise definition). Taking the design principle "contrast" as an example, it lacks formalization and precision, as there is no standardized numerical measure to define "contrast." Instead, students learn the concept by developing subjective interpretations by studying the works of masters and participating in design practice.

Abstract words, which are inherently nonspecific and intangible, contribute to vagueness. Examples include concepts such as "love," "inequality," or "freedom." Designers can use abstract words like "freedom" to express complex ideas, rather than relying on concrete descriptors such as "bus" [11]. This approach fosters creativity by encouraging wider conceptual thinking [47], however, processing abstract words is frequently slower and less precise, as it requires extensive contextual analysis to discern meaning [38]. F7 noted that a 2-hour class, during which students present their abstract ideas alongside a project, could often extend to 3 or 4 hours. This cognitive complexity can lead to misunderstandings, fatigue, or delays in processing information, particularly in collaborative settings [42].

The insights gained through this study underline the critical role of linguistic accessibility in graphic design education and professional discourse. We were thus inspired to design Ekphrasis, aiming to assist students to engage more effectively across diverse linguistic contexts.

4 System Design and Development

In related work, we discovered that visual aids often outperform language-centered approaches as a tool for teaching various subjects. A visual-centered approach is both appropriate and effective for addressing the communication challenges identified in the formative study. To this end, we developed Ekphrasis, aiming to visualize and simplify graphic design language, and create a more inclusive and engaging educational environment.

The digital interface utilizes blocks in compositional studies to reflect a hands-on approach, Gestalt composition. This method is commonly used in foundational graphic design education, where students are often presented with an ambiguous and vague prompt, such as "safe and efficient (Figure 2: Traditional Classroom Practice)." They then physically arrange paper blocks to interpret and achieve the prompt, facilitating their understanding of Gestalt theory and deepening their knowledge of layouts and user interface design [50]. Our adaptation not only mirrors the traditional approach but also extends its application, leveraging blocks as a critical learning tool in the digital domain. Fosco et al.'s research highlights the relevance of this concept, they developed a deep learning tool based on the pre-conceived notion that human attention simplifies visual elements into block forms, enabling predictions of visual importance in graphic images and saliency in natural images [17]. This underscores the enduring significance of blocks as both a cognitive framework and a practical tool in understanding and designing visual compositions.

When learning with Ekphrasis, the user makes a composition on the canvas to achieve a design goal X (e.g. visual harmony). Ekphrasis records the color and position coordinates (x,y) of the blocks on the user's composition, and generates 10 variations by randomly adjusting the poison and area of these blocks based on users' composition and saves these generated variations as PNGs. The variations are then fed into a ML model to choose the least X and the most X variation. Then the GUI displays the 2 variations chosen by the model, showing an X spectrum.

We modified a VGG16 model [1, 29], retaining its feature extraction capabilities while adding new layers tailored for binary

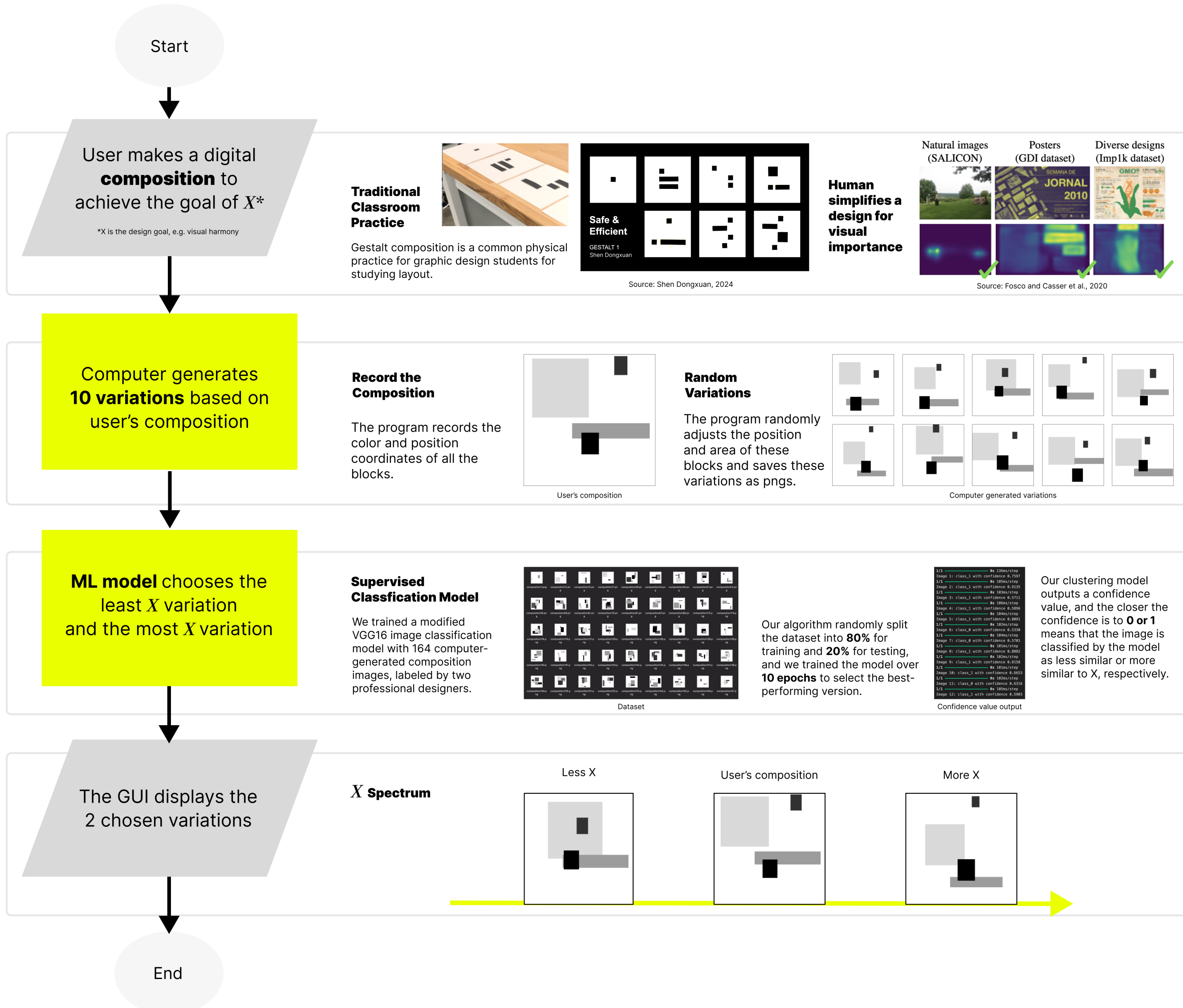

Figure 2: The flowchart shows the system design of EKPHRASIS. This educational system digitalizes traditional Gestalt composition study [17, 50] and tasks students with composing designs intentionally to achieve challenging graphic language goals, such as "visual harmony." It provides real-time visual aids that are generated based on the student's composition and selected using a modified VGG16 [1, 29] supervised classification model. By presenting a less successful iteration alongside a more successful one, EKPHRASIS helps students strengthen their comprehension and improve their design skills.

classification. The model was optimized with binary cross-entropy loss and the Adam optimizer and trained on a custom dataset to distinguish between "class 0" and "class 1." The dataset, divided into 80% training and 20% testing subsets, was evaluated through multiple runs to identify optimal performance. The model demonstrated predictive outputs that aligned closely with expert perceptions, categorizing 164 auto-generated images into "harmonious" and "disjointed" classes, with accuracy ensured by professional designer labeling.

5 Preliminary testing in a graphic design education context

We hypothesize that our designed system can help students better understand the connection between linguistic expressions and visual representations in graphic design. Through this system, we aim to explore how students comprehend these conceptual terms through visual aids.

Following the formative interviews, we found "visual harmony" a representative term that is ambiguous, vague, and even "a bit jargon-like" [34](F2, F10). As teachers often observed students struggling to understand this concept (F3), we selected it as the current prompt for Ekphrasis. "Visual harmony" frequently emerges during critique sessions to describe a design's overall composition and rhythm, reflecting the idea that "...elements...form a consistent and orderly whole" [32]. Notably, "harmony" carries abstract meanings, such as "feeling or sentiment; peaceableness" [33], and serves as jargon within musical contexts, where it refers to "the combination of musical notes" [34]. These diverse meanings make the term a prime example of ambiguity. It also exemplifies underspecification, given that there is no universal definition of "harmony" in graphic design.

5.1 Experiment Design and Analytical Method

We developed a detailed plan for a future study, selected two participants with zero or limited understanding of graphic design and conducted pilot studies individually to confirm that this protocol is feasible. Following the protocol, each participant was first shown widely acknowledged designs exemplifying "visual harmony" to establish a foundational reference. They then created their first composition using Ekphrasis while verbalizing their design decisions through a "think aloud" protocol. Upon completion, Ekphrasis provided visual feedback, which the participants used to reflect and adjust their compositions. This cycle of creation, feedback, and iteration repeated twice. User interactions with the graphical user interface (GUI) were recorded for detailed analysis. The study concluded with participant reflections gathered through Zoom interviews, focusing on their learning experiences and the perceived impact of the feedback provided by Ekphrasis. To analyze these reflections, we employed Reflexive Thematic Analysis [3, 4], where the first authors systematically reviewed the transcripts, conducted coding, and iteratively refined themes to capture participants' insights [7, 23]. Success metrics include verbal feedback and recognition, providing insights into the system's facilitation of design comprehension.

5.2 Participants' Observations

The participants expressed satisfaction with the comparative visual aids. They noted that it helped them quickly grasp unfamiliar design terms and enabled them to associate the success of their designs with varying levels of visual representation effectiveness (P1, P2).

The participants successfully developed subjective definitions of "visual harmony" during the study. P1 commented, "Visual harmony feels like achieving balance, and disharmonious compositions shift attention unevenly," while P2 wondered, "Is the essence of visual harmony about lower 'contrast'?"

While creating their compositions, the participants drew on the reference designs provided and carefully considered how various design elements influenced the overall composition. P1 observed, "Color, size, and shape have different weights that together determine how it captures attention." P2 made an analogy: "If all the elements in the composition are of the same size, it creates a feeling akin to a perfect chord–or a stronger sense of harmony."

We took participant suggestions to iteratively enhance Ekphrasis's usability, improving existing functionalities and introducing new features. P1 was presented with an earlier iteration of the interface, which was left-aligned. They suggested adopting a center-aligned layout to prevent participants from perceiving the GUI's layout as part of the compositional element, thereby minimizing potential distractions. Additionally, the interface was sent for professional evaluation, where F4 and F10 recommended a minimalistic aesthetic to help reduce cognitive load and maintain user task engagement [42].

The study indicates an improvement in participants' design compositions following iterative feedback cycles. Professional designers (F4, F11) assessed second-round compositions as superior to initial attempts, noting enhanced visual harmony, balance, and compositional clarity. Participants also showcased an increasing ability to articulate their design rationale during the study. Speeches during the "think-aloud" sessions were longer in the second round, demonstrating deeper engagement and conceptual understanding. Participants discuss "visual harmony" more frequently in their reflections, suggesting improved internalization and application of design principles.

The preliminary test confirmed our study protocol is feasible. Ekphrasis shows the potential to assist students in understanding the connection between linguistic expressions and visual representations, laying the groundwork for future experiments, where additional design terms will be introduced and a broader participant group will be engaged.

6 Discussion

This study highlights the potential of machine learning to address miscommunication in graphic design education. However, certain inherent limitations of machine learning need consideration. The dataset used to train and validate the AI model was limited in size and lacked sufficient diversity in its labeling categories. Therefore, the findings may not be fully generalizable and could unintentionally reflect biases stemming from the dataset's composition rather than accurately representing broader creative contexts [5]. Moreover, machine learning models often face challenges in interpreting complex contexts and subjective design subtleties. We will focus on diversifying datasets and expanding the usability testing with a larger participant group to strengthen the validity of the findings, clarify how different user groups–students, educators, or industry professionals—might engage with the tool to enhance its broader applicability. By addressing these gaps, we can enhance the robustness, equity, and applicability of the model.

Beyond graphic design education, this approach holds potential applications in other visual driven contexts, such as architecture, UI/UX design, and technical communication, where bridging linguistic descriptions with visual representation remains a challenge.

7 Conclusion

The study explores the linguistic challenges in graphic design education, often arising from jargon, ambiguity, and vague terminology. Through interviews and reflexive thematic analysis with 11 renowned educators and designers, we identified key communication barriers and subsequently developed an interactive educational system, Ekphrasis. Ekphrasis digitalizes traditional composition studies and provides real-time, actionable visual aids with an embedded supervised classification model, aiming to improve students' subjective understanding of graphic design vocabulary. Preliminary testing revealed notable improvements in participants' design composition, indicating the potential of Ekphrasis to facilitate intuitive learning. Future research will focus on broadening participant demographics, expanding datasets, and diversifying the labeling team to refine the model further. We hope this study contributes to graphic design education and serves as an opportunity to build inclusive, accessible multi-modal educational frameworks.

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