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The role of semantic stimuli in enhancing creativity in art and design education

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Introduction: Previous studies have emphasized the role of verbal stimuli in fostering creativity, yet a systematic exploration of semantic stimuli within the context of art and design education remains scarce. This study aims to empirically investigate the effects of different types of semantic stimuli, the proactive application of creativity evaluation criteria, and the role of individual differences in the process of generating design ideas.

Methods: A semantic stimulation intervention using verbal stimuli was conducted with 409 university students from the School of Art and Design and the School of International Education. Verbal semantic stimuli, unlike visual or auditory forms, offer a controllable and cognitively integrative format suitable for precise application in design education. First, expert commentary terms were introduced as semantic stimulus materials to enhance their relevance and effectiveness in educational settings. Second, creativity evaluation criteria were transformed from traditional outcome assessment tools into thinking guidance tools, applied at the early stages of the design process.

Results: Both abstract and concrete semantic terms were found to effectively stimulate students' creative thinking. Creativity evaluation criteria were shown to function not only as tools for post-project assessment but also as guides for creative thinking during the early stages of design. Chi-square tests revealed that individual differences, such as participants' educational background and major, significantly influenced their preferences for using semantic stimuli and their performance in idea generation.

Discussion: This study provides a practical semantic stimulation method for art and design education, promoting a shift in teaching models from experience-driven approaches to rational guidance. It also offers a new form of support for design practice during the concept generation phase.

KEYWORDS

art and design education, creativity stimulation, semantic stimuli, expert commentary words, proactive evaluation criteria

1 Introduction

1.1 Research background

In contemporary art and design education, cultivating creative idea generation is regarded as one of the core objectives. Traditionally, teaching practices have mainly relied on visual stimuli—such as images, colors, and forms—to inspire students' creativity and conceptual thinking. However, with the introduction of semantic theories, linguistic vocabulary, especially words serving as “semantic stimuli,” has increasingly been recognized as an important resource

for fostering creative thinking, due to its high level of abstraction and conceptual integration.

It is important to clarify here that “semantic stimuli” as a general term may encompass various forms—verbal, visual, auditory, or experiential (e.g., memories)—but the present study focuses specifically on the verbal format, i.e., semantic words, due to their distinctive advantages in design education contexts. Compared with other types of stimuli such as images or sounds, semantic words can convey conceptual cues, are easier to standardize across participants, and can be precisely classified and manipulated along dimensions like abstraction, evaluative intent, or disciplinary specificity. These features make them especially suitable for empirical investigation and application in structured educational interventions.

In recent years, researchers have begun to pay attention to the potential role of semantic stimuli in design education, pointing out that it not only helps students reconceptualize problem contexts but also acts as a cognitive trigger mechanism for concept construction and transformation (Casakin and Georgiev, 2021). Analyzing dialog during design activities has been shown to deepen the understanding of design thinking and its relationship with creativity. Nevertheless, despite the confirmed positive effects of semantic stimuli on creativity, their application in practical educational settings still exhibits many shortcomings, necessitating further systematic research.

A key area that demands deeper empirical attention is the mechanism by which different types of semantic stimuli—particularly abstract versus concrete terms—affect creative generation in design education. Studies have suggested that abstract words often involve complex conceptual integration, promoting distant associations, while concrete words tend to facilitate imagery-based thinking and the generation of specific solutions (Villani et al., 2019). Although these theoretical distinctions are acknowledged, systematic comparative studies validating their differentiated effects in design learning contexts remain lacking.

Closely related to this issue is the transformative potential of creativity evaluation criteria, which have traditionally been confined to post-hoc assessments. Mainstream creativity evaluation tools, such as the Torrance Tests of Creative Thinking (TTCT), are typically used for standardized post-project evaluations (Kim, 2006). In contrast, the novel Evaluation of Creativity in Action Tool (ECAT) proposed by Akdemir-Beveridge et al. (2025) emphasizes introducing multidimensional evaluation at the early stages of the design process to guide students’ depth and diversity of thinking. Although this tool has shown preliminary success in engineering education, its adaptation and validation in art and design education are still lacking.

These two gaps—the need to understand how semantic stimulus types affect creativity and the need to recast evaluation criteria as formative guidance tools—form the central problem this study aims to address. Surrounding these core issues are several related but currently less developed areas of inquiry that provide important context. For example, the use of expert commentary terms as semantic stimuli represents a promising but underutilized direction. Such terms, often drawn from professional design critiques and competition evaluations, possess a high degree of disciplinary relevance and evaluative orientation. Compared with common words such as “nature” or “dynamics” (Goldschmidt and Sever, 2011), these expert terms may better sensitize students to qualities associated with high-level creativity. Yet their practical application in educational contexts remains an exploratory endeavor lacking systematic validation.

Another consideration is the role of individual difference factors in moderating the effects of semantic stimuli and evaluation criteria. Research by Denervaud et al. (2021) indicates that educational experiences shape individuals’ semantic network structures and influence their creative performance. However, there remains a lack of systematic experimental studies among students majoring in art and design, which limits our understanding of how such participant-level variables interact with semantic and evaluative guidance mechanisms.

In summary, while the value of applying semantic stimuli in art and design education is increasingly recognized, research on the types and characteristics of stimuli, the incorporation of expert corpus, the proactive guidance role of evaluation criteria, and the impact of individual differences remains insufficient. Therefore, this study aims to explore the following three areas in depth: (1) Selecting sources of stimuli and analyzing the differential effects of abstract and concrete semantic stimuli in inspiring creative idea generation; (2) Constructing creativity guidance based on different dimensions of creativity evaluation criteria, applied proactively at the early stages of the design process; (3) Investigating the effects of participants’ academic background and educational attainment on the effectiveness of semantic stimuli, with the goal of providing a more targeted and empirically supported semantic guidance strategy for art and design education.

1.2 Research content

The research questions of this study are: (as illustrated in Figure 1).

- (1) How do the source and semantic type of stimuli inspire creativity in art and design education?
- (2) How does the expansion of application dimensions of creativity evaluation criteria influence creative idea generation among design students?
- (3) How do other participant factors, especially educational background and major, affect the creative generation process?

Structure of the Paper: The first part reviews the literature and related studies on semantic stimuli, creativity evaluation criteria, and other factors influencing participants’ creativity. The second part details the experiment, where qualitative and quantitative methods are used to select and categorize semantic stimuli, apply creativity evaluation criteria as proactive guidance, and conduct correlation analysis considering participant factors. The third part analyzes the research results through descriptive statistics and chi-square tests, and discusses their implications for design education and practice.

2 Literature review and related research

2.1 Inspiration stimuli and semantic stimuli

Inspiration stimuli (such as images, objects, or abstract concepts) serve as external inputs that spark and support creative thinking during the design process. Studies have explored the effects of different types of stimuli on design creativity. For instance, Hou (2023)

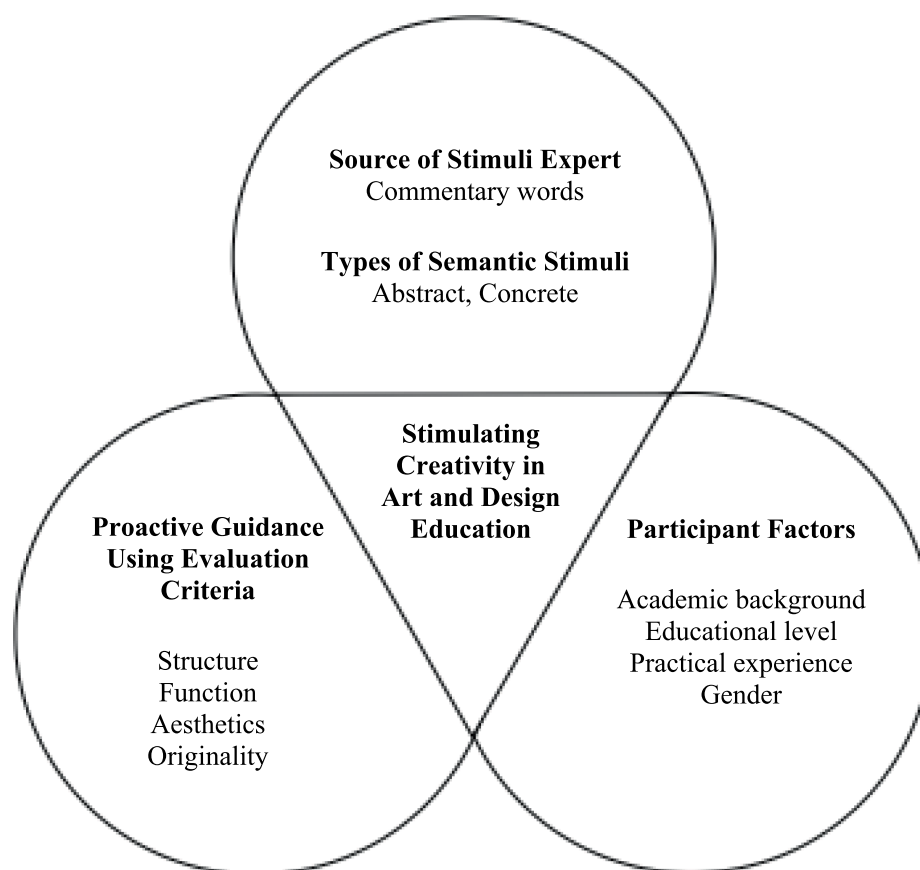


FIGURE 1
Diagram of research content.

investigated the impact of design inspirations from near, medium, and far domains, finding that far-domain inspirations enhanced the novelty of the solutions generated by designers. These stimuli are often classified based on their form and analogy distance (Blandino et al., 2023; Jia et al., 2020). Goucher-Lambert et al. (2020) examined the role of stimuli in creativity, using latent semantic analysis to identify adaptive stimuli and proposing real-time design monitoring measures. Blandino et al. (2023) systematically reviewed the influence of stimuli and other factors (such as time and designer background) on idea generation in conceptual design processes.

Although designers typically prefer visual stimuli (Cascini et al., 2019; Gonçalves et al., 2014), other forms such as sketches and text-based stimuli can also affect creativity, sometimes facilitating or hindering the creative process (Atilola et al., 2015; Goldschmidt and Sever, 2011). Existing literature emphasizes the significant role of inspiration stimuli in design ideation and creativity (Bacciotti et al., 2016; Guo and McLeod, 2014; Hao et al., 2019; Saliminamin et al., 2019).

Beyond visual stimuli, verbal and semantic stimuli are also recognized as important influences on creative output. Semantics refers to the meaning of words expressed through separable features, which together form the complete meaning of a word. The fundamental purpose of semantic stimuli is to expand cognitive boundaries, break habitual thinking patterns, and serve as tools for fostering divergent thinking across different groups. Earlier theories described word meanings through feature lists and compiled feature sets for concrete

and abstract words, although such sets might not capture all relevant meanings. Vigliocco and Vinson (2007) emphasized the importance of gathering feature information from multiple speakers to assess significance. Zahner et al. (2010) studied the effects of concrete (domain-specific) and abstract (domain-general) stimuli on idea generation, finding that abstraction could stimulate novel ideas during the divergent phase but might reduce their practicality during the convergent phase. This suggests that while abstract stimuli can generate new ideas, their practical applicability needs to be reassessed.

Georgiev and Georgiev (2024) explored the use of dynamic semantic networks to investigate creative thinking, demonstrating that semantic measurement can effectively assess and enhance creativity in design education. This highlights the potential of linguistic elements as catalysts for creative thinking within design environments. Kivisaari et al. (2024) conducted a cross-method and cross-linguistic comparison of semantic feature norms, again stressing the importance of collecting feature information from multiple speakers. Wise and Kenett (2024) showed that automatically generated word suggestions could encourage creativity, emphasizing the role of semantic associations as metacognitive cues.

Moreover, Wang et al. (2024) found through EEG studies that participants exhibited significantly enhanced brain activity during design ideation tasks after receiving semantic feedback, indicating that semantic feedback can boost students' cognitive engagement and creative thinking abilities.

These findings collectively underscore the crucial role of semantic stimuli in nurturing creativity. However, in art education, the challenge remains: how to select appropriate semantic words and effectively leverage semantic stimuli to unlock students' creative potential and broaden their paths to creativity.

2.2 Creativity evaluation metrics

In recent years, the assessment of design creativity has received widespread attention. Building on earlier work that identified novelty, diversity, quality, and quantity as key metrics, [Vasconcelos and Crilly \(2016\)](#) further emphasized originality and relevance. [Runco \(2023\)](#) pointed out that structure and function address issues of usability and practicality, aesthetics focus on emotional and visual engagement, and originality reflects the assessment of novelty and innovation. [Blandino et al. \(2023\)](#) conducted a systematic review on the role of stimuli in idea generation, highlighting the importance of introducing metrics such as novelty, diversity, quality, and quantity to evaluate participants' performance. These metrics are crucial for assessing the effectiveness of stimuli in enhancing creativity during the design process. Additionally, [Owen and Roberts \(2024\)](#) proposed the Rowen Test for visualizing design creativity, focusing on four metrics: quantity, correctness, novelty, and feasibility. This test aims to provide a structured method for evaluating creativity in visual design, promoting objective assessment and fostering innovation.

Traditional creativity evaluation has mostly focused on outcome-based approaches, emphasizing objective metrics such as the novelty, practicality, and refinement of works. However, in recent years, researchers have begun to emphasize the role of evaluating the creative process itself. [Jiang et al. \(2019\)](#) mentioned in their study that methods for assessing creative thinking have gradually shifted from traditional outcome orientation to a focus on the design process.

These studies collectively highlight the evolving methods and metrics used to assess and enhance creativity, emphasizing the importance of structured assessment tools and the integration of various metrics to promote innovative outcomes. However, no research has yet directly applied creativity evaluation metrics proactively to guide initial thinking in order to stimulate students' early-stage idea generation in design.

2.3 Other factors influencing participants' creativity

In experimental studies on idea generation, [Blandino et al. \(2023\)](#) pointed out that several factors influence participants' performance, including background, expertise, experience, and gender. Referring to this study, we propose, for students in art and design fields, to investigate the impact of semantic stimuli on creativity by using variables such as academic background, educational level, practical experience, and gender.

In this study, "Academic background" refers to the different disciplines or majors of the participants.

Recent research indicates that interdisciplinary collaboration in design education can enhance creativity and problem-solving abilities. For example, [Fleischmann \(2022\)](#) discussed the integration of unrelated disciplines into design classrooms, highlighting both the benefits and

challenges of this approach. [Zheng et al. \(2022\)](#) analyzed a large number of scientific publications and patents, concluding that teams with diverse expertise can produce more original and longer-lasting works. Similarly, [Ou et al. \(2023\)](#) found that binary teams composed of designers and non-designers generated more original and useful design ideas compared to homogeneous teams. [Todoroff et al. \(2021\)](#) compared the design thinking traits between samples of civil engineering and architecture students across various institutions in the United States. There is a significant difference in perceived design thinking ability between the groups. These findings suggest that diverse academic backgrounds can positively impact creativity in design education.

In this study "Educational level" refers to whether participants are graduate students or undergraduates.

An earlier study ([Cheung et al., 2003](#)) investigated the effects of students' majors and years of study on creativity. The study found that level of study (diploma vs. degree) and prior academic performance were significant predictors of divergent thinking abilities. This suggests that the educational process and academic background influence creativity. A longitudinal study at a Korean engineering university examined the relationship between students' creative potential and academic performance ([Kim, 2020](#)). The results indicated that creative potential improved over 4 years, particularly in aspects such as fluency and originality. This shows that higher education can enhance certain aspects of creativity over time. These studies suggest that educational level can influence creativity through factors such as duration of study.

In this study, "Practical experience" is represented by the length of time participants have been engaged in design practice.

[Phothong et al. \(2023\)](#) observed that students with design experience exhibited a more developed design thinking mindset after participating in design-based learning activities. [Samaniego et al. \(2024\)](#) conducted a systematic review emphasizing the role of experiential learning in fostering creative thinking in art and design education. Their study highlighted that hands-on learning environments help cultivate core creativity. These findings suggest that the duration and intensity of participation in design practice projects are positively correlated with the enhancement of creativity.

"Gender" studies have shown varying results regarding gender differences in design creativity.

Research by [Luo et al. \(2023\)](#) indicated that gender stereotypes in creativity might hinder female students' development of creative self-efficacy in visual arts education. Conversely, other studies suggest that female students may excel in certain aspects of design thinking. For instance, a study by [Cañizares et al. \(2023\)](#) published in *Frontiers in Education* found that, compared to male students, female students had more positive impressions and perceptions regarding methods for participating in idea generation.

Although the studies mentioned above have validated the influence of these four participant factors on creativity, in the context of art and design education, further exploration is needed on how to appropriately define participant factors and investigate their impact on the stimulation of creativity through semantic stimuli.

2.4 Summary

In summary, existing literature has highlighted the importance of using verbal stimuli to foster creativity, established evaluation metrics for assessing and enhancing creativity, and validated the influence of

other participant factors on creativity. However, in the context of art and design education, how to effectively leverage semantic stimuli to stimulate students' creative potential and broaden their avenues for idea generation; how to select creativity evaluation metrics as proactive guidance based on educational performance to assess their role in idea generation; and how to appropriately define participant factors and explore their impact on creativity stimulated by semantic stimuli—all these aspects still require further investigation. This paper will conduct experimental research on these issues.

3 Materials and methods

To differentiate from previous studies that generally selected semantic stimuli, this study used expert commentary words as semantic stimuli. These were classified based on semantic types and creativity evaluation tendencies and applied during the initial phase of the design process to guide thinking. The study explored the effect of semantic stimuli on enhancing creative thinking in art and design education. The goal was to evaluate the role of semantic stimulus types (concrete, abstract), creativity evaluation orientations (structure, function, aesthetics, originality), and other participant factors (academic background, education level, practical experience, gender) in stimulating creativity among students majoring in art and design.

To achieve this objective, we followed three steps:

- (1) Experts extracted commentary words based on the visual stimuli of award-winning works from world-class competitions.
- (2) Commentary words were classified and validated based on semantic type and creativity evaluation orientation.
- (3) Chi-square tests were conducted on semantic stimuli, creativity evaluation orientations, and participant factors.

3.1 Step one: extracting commentary words from visual stimuli of award-winning works by experts

3.1.1 Sample selection

This study used award-winning designs from the '2020 WorldStar Global Packaging Awards' as visual stimuli. This award,¹ organized by the World Packaging Organization (WPO), represents the highest recognition for outstanding packaging designs worldwide and indicates trends in packaging design development. These award-winning designs were selected because their creativity and innovation had been recognized, ensuring high-quality examples of design principles. The awarded works serve as effective triggers for new ideas, representing a diverse range of creative excellence.

3.1.2 Data collection

We invited seven experts (six males and one female) with over 20 years of design experience, all of whom had served as design judges at various design workshops. The task for the expert judges was to evaluate each provided award-winning design (visual stimulus) and

write a brief response (a word or short phrase, i.e., commentary word) under each design, commenting on why they believed the design had won an award. Each expert was required to provide 20 or more words or phrases. Figure 2 shows an example of our visual stimuli set along with the commentary words provided by one of the experts.

3.2 Step two: classification and validation of commentary words based on semantic types and creativity evaluation orientations

3.2.1 Classification of semantic types and creativity evaluation orientations of commentary words

We provided a set of commentary words obtained from expert opinions to 51 design faculty members with extensive design experience. These faculty members were asked to classify each word according to two semantic types and four creativity evaluation orientations: that is, 'abstract or concrete' semantic types, and 'structure, function, aesthetics, originality' orientations. This step ensured that the final word set represented different semantic attributes.

This study selected abstract and concrete as the semantic classification dimensions for the following reasons: First, the cognitive manner in which semantic stimuli are processed directly affects the outcomes of idea generation. Abstract and concrete representations each have unique advantages in activating thought processes and together can meet the full-spectrum needs of design thinking, from conceptual exploration to practical implementation. Second, these categories may align with the staged characteristics of design education and the differentiated needs of various design disciplines regarding the abstract–concrete dimension.

This study chose structure, function, aesthetics, and originality as the classification dimensions for creativity evaluation tendencies based on the following considerations: Creativity assessment must balance practicality and aesthetic innovation. In the field of design education, design competitions are often used as key measures of teaching effectiveness, and their evaluation criteria typically encompass multiple dimensions, such as structural rationality, functional performance, aesthetic expression, and conceptual originality. Unlike previous studies, this study innovatively expanded the application of these criteria in two ways: First, as a basis for classifying the semantic stimuli; second, by transforming them into thinking guidance tools during the early design stages to systematically stimulate creative potential through proactive dimension setting. This dual application not only maintains the educational relevance of traditional evaluation standards but also overcomes the limitation of their use solely as post assessment tools.

The classification of expert opinions served two purposes: First, this process enabled a systematic assessment of the impact of different types of stimuli on creativity, providing a method for evaluating how semantic words align with design thinking. Second, It helped establish clearer links between specific stimuli and creativity evaluation tendencies, aiding the conceptual design process through semantic word classification.

To enhance consistency in classification, a preparatory coordination session was conducted with all 51 faculty members prior to the formal classification. During this session, representative sample words were used to calibrate understanding of the semantic types

¹ <https://worldstar.org>

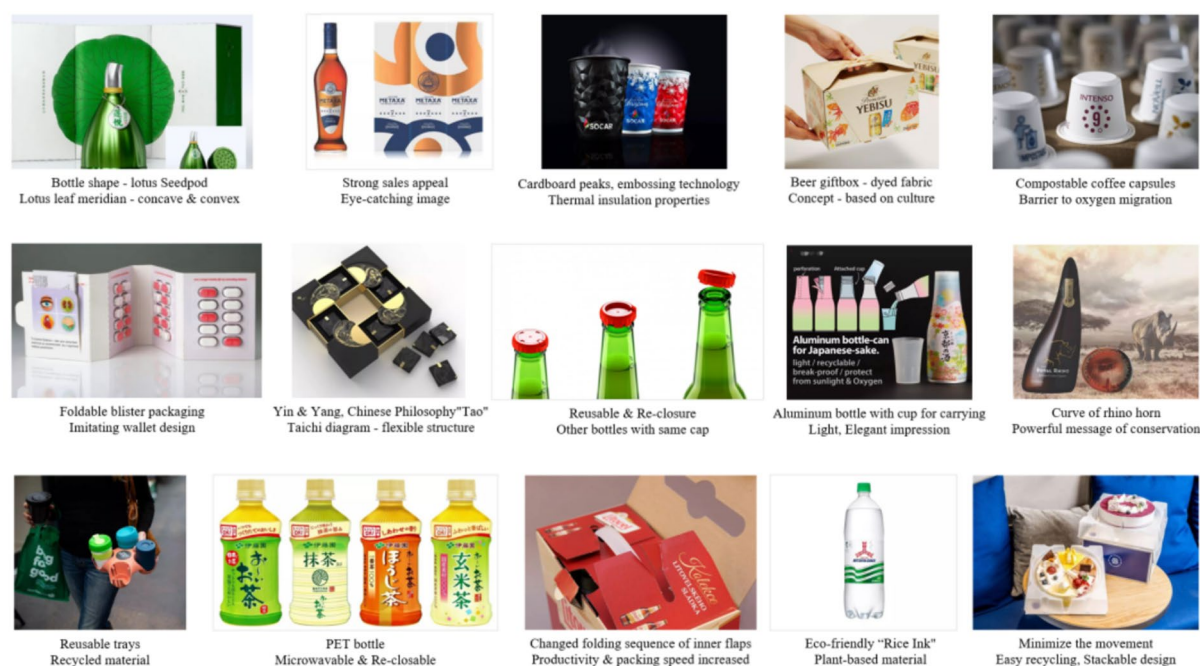


FIGURE 2

Example: expert commentary on selected award-winning works.

(“abstract” vs. “concrete”) and creativity evaluation orientations (“structure,” “function,” “aesthetics,” and “originality”). Faculty members discussed edge cases and clarified ambiguous terms to ensure a shared conceptual understanding. All data processing operations were subsequently carried out by two independent researchers with expertise in design and semantic analysis, who followed a predefined coding protocol to categorize the words. Preliminary trial coding ensured consistency, and in cases of disagreement, coders engaged in structured discussion with a third reviewer to justify and align their judgments based on shared criteria and contextual usage in design discourse. The classification of words as “abstract” or “concrete” was grounded in both linguistic definitions and design cognition principles: abstract words were defined as those referring to intangible qualities, emotions, or conceptual constructs (e.g., “balance,” “innovation”), while concrete words referred to physical forms, sensory experiences, or tangible phenomena (e.g., “texture,” “curve”). These definitions were informed by cognitive linguistics literature and refined through the faculty discussion process.

3.2.2 Survey on the effectiveness of commentary words in stimulating creativity

3.2.2.1 Participants

We recruited 409 students from China, studying at two schools: the School of Art and Design and the School of International Education. Participants joined voluntarily via the university’s online platform. Their demographic information is as follows: 107 males and 302 females; 242 students majoring in Visual Communication Design, and 167 students majoring in other design fields (such as Product

Design, Fashion Design, Digital Media, etc.); 371 undergraduate students and 38 graduate students. Among them, 47 students had more than 1 year of design experience, while 362 had less than 1 year of experience. Participants received participation credits for their involvement. Before the experiment, researchers explained the study’s purpose and procedures to participants in detail. Each participant gave informed consent and provided demographic information through a questionnaire. They were informed that all data would be used solely for research purposes, and they retained the right to withdraw or terminate participation at any time.

The division of participants by education level (undergraduate vs. graduate) followed the official enrollment status provided by their academic programs. Major categories were defined based on institutional curriculum tracks, with Visual Communication Design treated as a separate focus due to its relatively high enrollment and distinctive pedagogical characteristics. Although the sample sizes of the groups were not numerically balanced, the distribution reflects typical proportions found in comprehensive design schools in China. Therefore, the composition of the sample was deemed appropriate for exploratory analysis and aligned with common demographic patterns in art and design education.

3.2.2.2 Procedure

First, a quantitative survey was conducted via an online questionnaire distributed through the internet platform.² The

² <https://www.wjx.cn/>

(academic background, education level, practical experience, gender). The aim was to identify potential differences in how various semantic stimuli affected the target group, thus enabling more tailored educational interventions for different types of students.

each word indicates its ranking among the 30 most mentioned words.

Figure 4 shows the classification of the 30 comment words based on abstract and concrete semantic features. The higher the blue line percentage, the stronger the recognition of the word as having concrete features; the higher the green line percentage, the stronger the recognition of the word as having abstract features.

Figure 5 shows the classification results of the 30 comment words according to the four creativity evaluation indicators. The higher the blue line percentage, the stronger the recognition of the word's structural attributes; the higher the green line percentage, the stronger the recognition of functional attributes; the higher the yellow line percentage, the stronger the recognition of aesthetic attributes; and the higher the orange line percentage, the stronger the recognition of originality attributes.

4.2.2 Results of the survey on the effectiveness of comment-based semantic words in stimulating creativity

The results of the survey on the effectiveness of the comment words are shown in Figure 6.

4.2.2.1 Result 1

Based on the results of Tables 1, 2, we removed five words with unclear feature tendencies. The 25 most relevant words were selected for the effectiveness survey. Figure 6 presents the quantitative assessment of the effectiveness of these 25 words (excluding invalid questionnaires). On the X-axis are the semantic words ranked by frequency of mention. The Y-axis shows the percentage of participants who rated the effectiveness of each word in inspiring creativity, using the Likert scale. Low proportions of blue indicate low effectiveness,

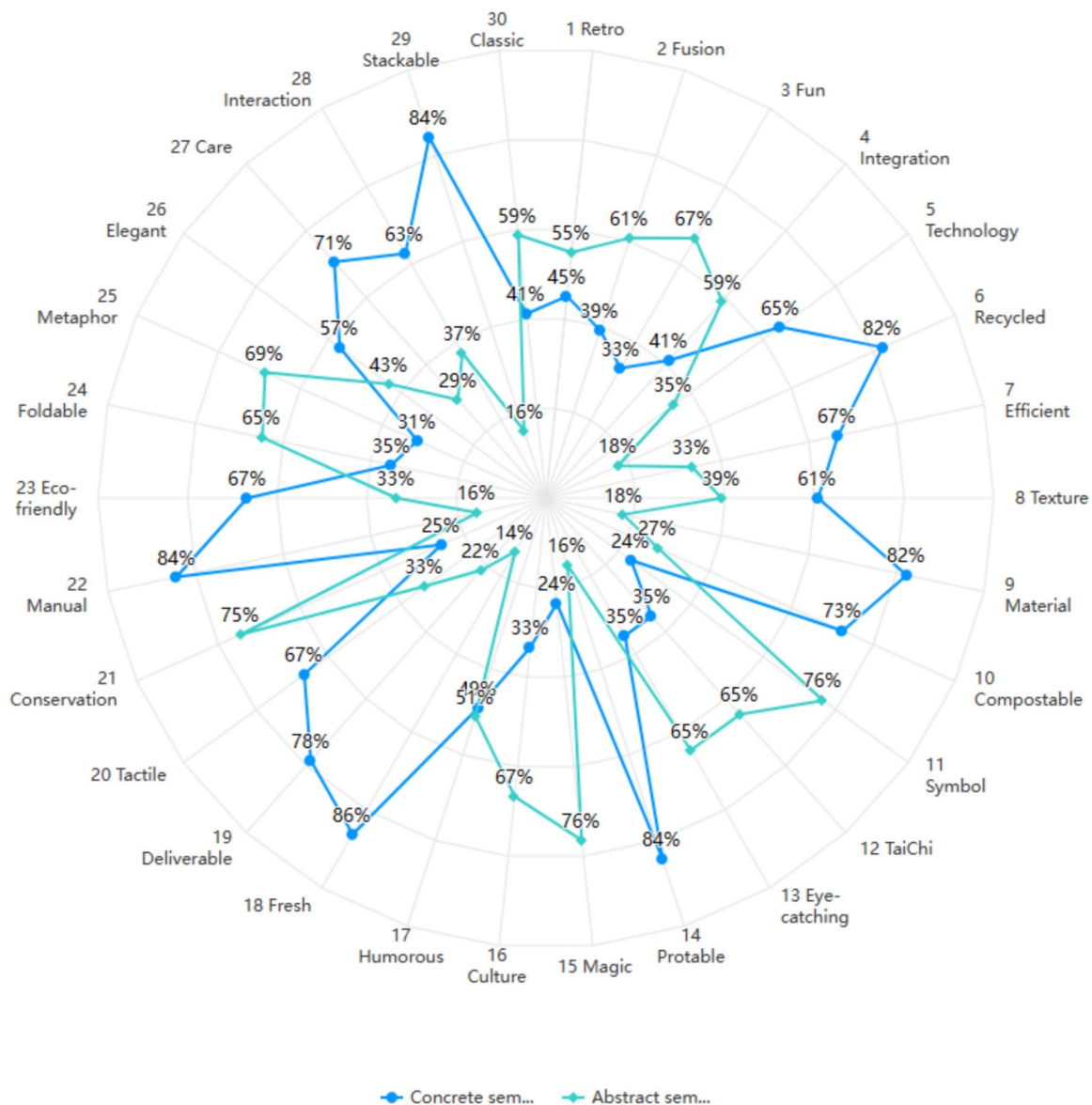


FIGURE 4
Classification of semantic word stimuli based on abstract and concrete features.

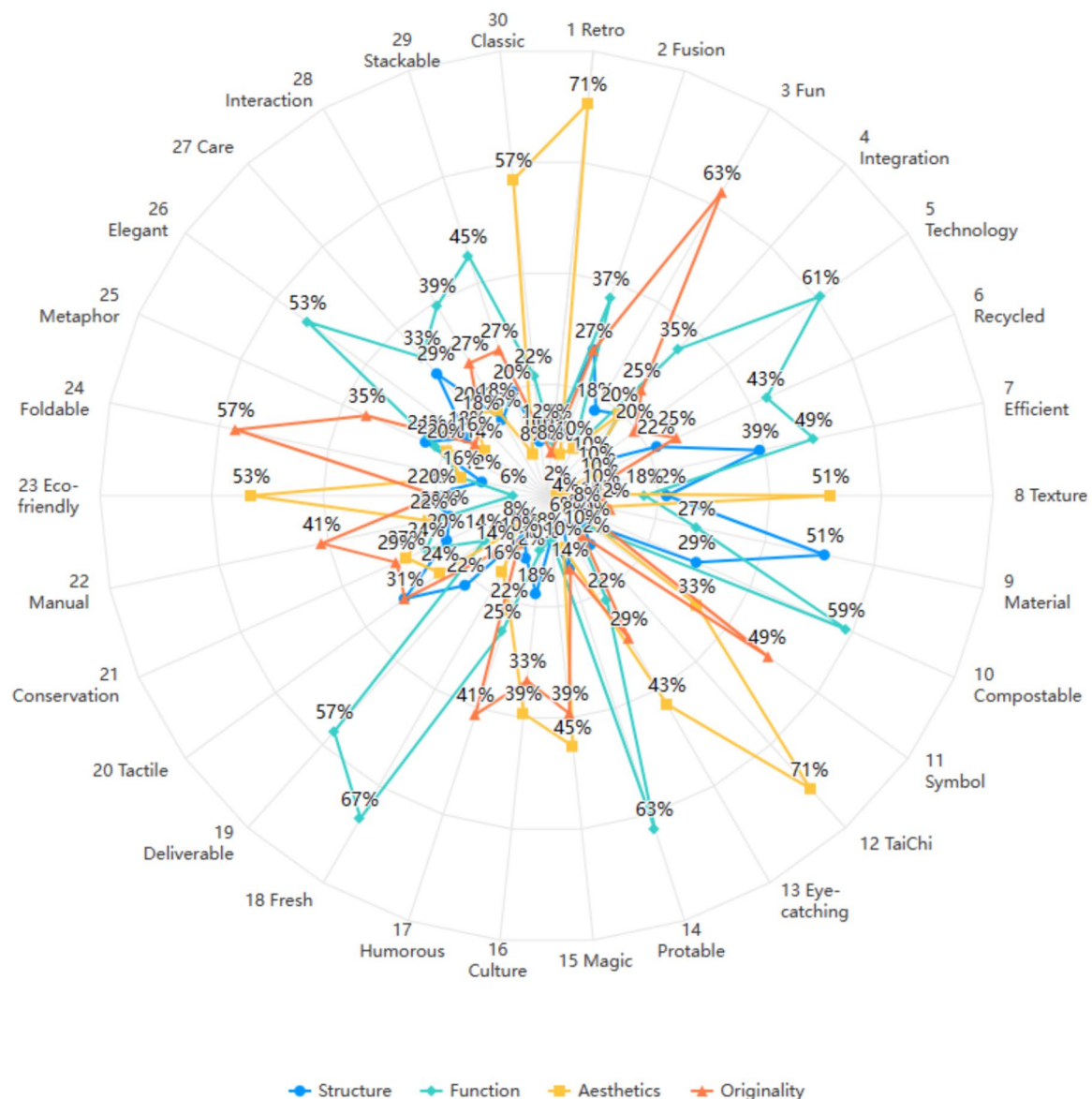


FIGURE 5
Classification of semantic word stimuli based on creativity evaluation indicators.

cyan indicates relatively low effectiveness, yellow indicates moderate effectiveness, orange indicates relatively high effectiveness, and high proportions of green indicate high effectiveness. From the quantitative results in Figure 6, it can be seen that for the 25 unclassified semantic words, the proportion of participants who selected 'high effectiveness' and 'relatively high effectiveness' was much higher than those who selected 'low effectiveness' or 'relatively low effectiveness'.

Similarly, the qualitative interviews confirmed these findings (Table 3): Among the nine interviewees, eight reported that they found it easy to draw inspiration from the high-rated words, for example, participant ID P9 mentioned, "[Elegance] inspired designs featuring natural forms and organic patterns. [Magic] triggered narrative-driven design ideas, both offering abstract inspiration." While only one reported difficulty in deriving concrete design ideas from them, for example, participant ID P3 noted, "[Culture] made me think more about user emotions and humanistic factors, offering

broader considerations beyond a single focus. However, it wasn't particularly strong in inspiring specific design ideas."

These quantitative and qualitative results were derived from an investigation of expert review words that had not yet been classified by semantic types or creativity evaluation indicators. Result 1 indicates that using unclassified expert review words as semantic stimuli is both feasible and effective.

For example, words such as "Elegance" and "Magic," though not yet categorized into specific semantic groups, were frequently cited by participants as effective in triggering creative ideas.

This also demonstrates that, regardless of whether the data were obtained through quantitative or qualitative methods, all unclassified semantic words had a significant impact on stimulating creativity. For instance, in the qualitative interviews, participants mentioned that "Elegance" inspired designs featuring natural forms and organic patterns, while "Magic" sparked narrative-driven, imaginative

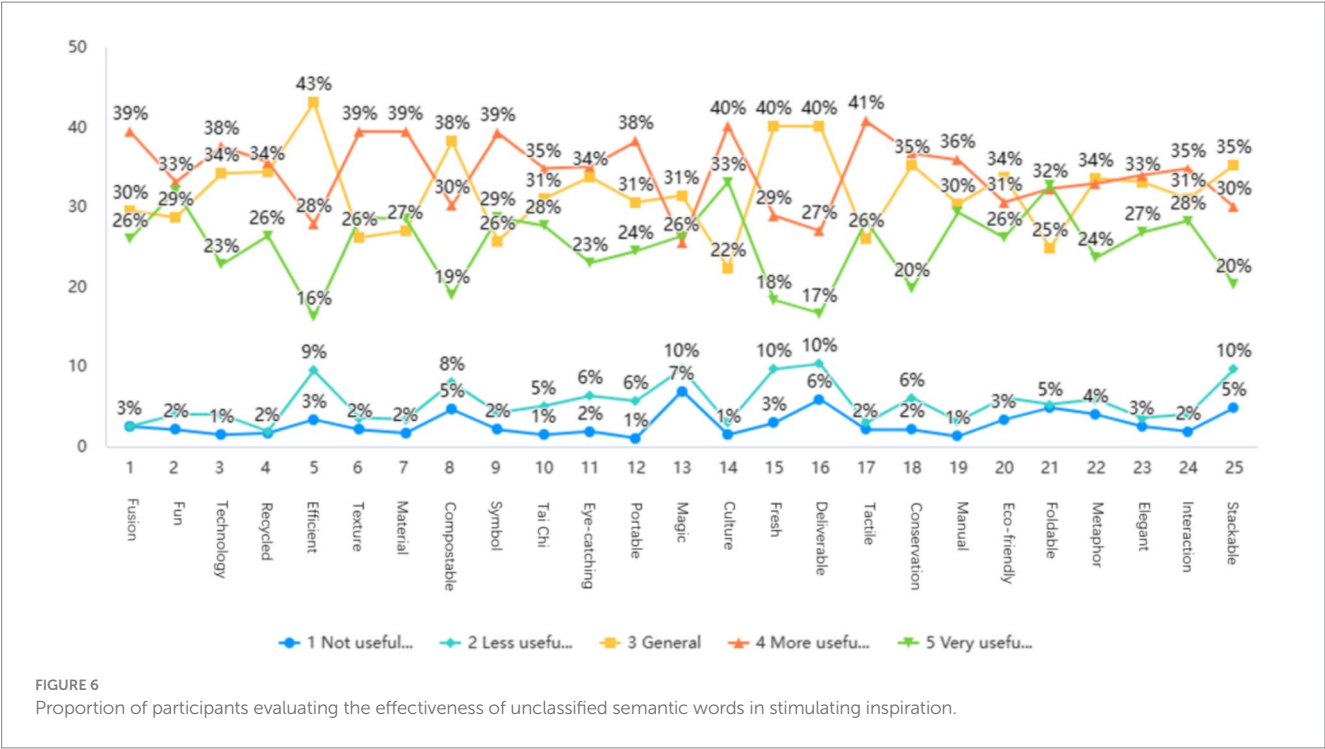


TABLE 1 Chi-square test result of abstract semantic feature vs. concrete semantic feature.

Test statistics	Value	Degree of freedom	Progressive significance
Pearson Chi-square	3086.247	1,364	0.001
Likelihood ratio	1035.779	1,364	1.000
Linear correlation	235.031	1	0.000
Number of valid cases	345		

TABLE 2 Chi-square test results of abstract semantic feature vs. education level.

Test statistics	Value	Degree of freedom	Progressive significance
Pearson Chi-square	47.932	31	0.027
Likelihood ratio	39.346	31	0.144
Linear correlation	9.325	1	0.002
Number of valid cases	345		

concepts—both offering abstract inspiration that contributed to ideation processes.

4.2.2.2 Result 2

Based on the 5-point Likert scale ratings, Table 4 presents the aggregated statistical data of the average effectiveness scores of words

after classification by semantic type and creativity evaluation indicators. From the table, it can be seen that for each semantic word—whether it belongs to the abstract or concrete type—the average effectiveness score is above the median value of 3. The four creativity indicators—structure, function, aesthetics, and originality—also show the same trend. This suggests that the classified expert review words remain reasonable and effective when used as semantic stimuli.

4.2.2.3 Result 3

Differences exist among the classified groups shown in Table 4. In terms of effectiveness in stimulating creativity, abstract semantic words (3.81) scored higher than concrete semantic words (3.48). Words related to aesthetics (3.84) and originality (3.83) scored higher than those related to structure (3.75) and function (3.70). Moreover, abstract semantic words associated with aesthetics and originality showed higher consistency, while concrete semantic words associated with structure and function exhibited higher consistency.

Similarly, in the qualitative study (Table 3), two participants expressed their feelings about the expert review words during interviews: One participant chose the abstract word ‘elegance’ and responded that she believed the word would inspire designs featuring natural forms and organic patterns. This indicates that abstract words, through user cognition, become concretized in natural organic forms, forming metaphorical links from aesthetics to emotions, thereby guiding the visual expression of creative designs. Another participant, when discussing the concrete word ‘portability’, emphasized that when designing a ‘bottle with a handle’, it naturally led to associations with ease of use and comfort. This illustrates that concrete elements can enhance the cognitive clarity and functional linkage of abstract concepts. These findings are consistent with the quantitative results shown in Table 4. The participants’ qualitative evaluations further support the reliability of

TABLE 3 Excerpts from qualitative interviews with some participants.

ID	Gender	Education	Major	Semantic tendency	Word choices	Excerpts from interview results
P1	Female	Undergraduate	Visual communication	Abstract	Fusion, magic, conservation, symbol	“Fusion” made me think of combining sustainable concepts with traditional weaving techniques. “Magic” inspired surreal compositions, leading to a poster idea combining paper-cutting with AR technology. “Symbol” prompted me to reconstruct a brand using Oracle bone script.
P2	Male	Undergraduate	Visual communication	Concrete	Foldable, ink	“Foldable” sparked ideas for portable display booklets. These words made me associate with printed media and installation art, aiding design expression and presentation.
P3	Female	Undergraduate	Digital media	Both abstract and concrete	Culture, care	“Culture” made me think more about user emotions and humanistic factors, offering broader considerations beyond a single focus. However, it wasn't particularly strong in inspiring specific design ideas.
P4	Male	Graduate	Digital media	Abstract	Fusion, technology, metaphor	“Fusion” inspired me to incorporate ink-style comic elements into UI animations. “Technology” made me abandon skeuomorphic design and explore network visualization interactions. “Metaphor” led me to think about using visual symbols to guide user behavior.
P5	Female	Undergraduate	Fashion design	Concrete	Material, tactility, culture	“Material” made me think about real materials and their application contexts. “Tactility” inspired me to consider thermosensitive fabrics; combining it with “Culture” helped me create a transformable Hanfu sleeve design, improving my project score.
P6	Female	Undergraduate	Visual communication	Abstract	Culture, Tai Chi	“Culture” guided me back to the roots, such as using embroidery elements to create modern handbags. Abstract words helped prompt deeper cultural expressions.
P7	Female	Graduate	Visual communication	Both abstract and concrete	Deliverable, technology	I liked “Deliverable” because it pushed me to imagine how textual information could be visualized. “Technology” encouraged me to consider different technical expression methods.
P8	Male	Graduate	Product design	Concrete	Portability, degradability, stackable, interaction	“Portability” inspired me to design bottles with handles, considering ease of use. “Degradability” stimulated modular product joints using mortise-and-tenon structures with biodegradable plastics. “Stackable” helped me design better packaging structures. “Interaction” led me to add tactile feedback devices in children's dining chairs, which I would not have considered during undergraduate studies.
P9	Female	Graduate	Visual communication	Abstract	Elegance, magic	“Elegance” inspired designs featuring natural forms and organic patterns. “Magic” triggered narrative-driven design ideas, both offering abstract inspiration.

TABLE 4 Effectiveness scores of classified semantic words for effectiveness in stimulating inspiration.

Concrete semantic	Abstract semantic	Structure	Function	Aesthetics	originality
Technology 3.79	Fusion 3.87	Material 3.94	Fusion 3.87	Texture 3.92	Fun 3.94
Recycled 3.86	Fun 3.94	Portable 3.83	Technology 3.79	Tai Chi 3.88	Symbol 3.90
Efficient 3.45	Symbol 3.90	Fresh 3.55	Recycled 3.86	Eye-catching 3.88	Conservation 3.69
Texture 3.92	Tai Chi 3.88	Deliverable 3.42	Efficient 3.45	Elegant 3.56	Manual 3.91
Material 3.94	Eye-catching 3.73	Tactile 3.93	Degradability 3.54	Culture 4.05	Magic 3.86
Degradability 3.54	Magic 3.86	Foldable 3.82	Interaction 3.85	Eco-friendly 3.73	Metaphor 3.68
Portable 3.83	Culture 4.05		Stackable 3.55		
Fresh 3.55	Conservation 3.69	Mean	Mean	Mean	Mean
Deliverable 3.42	Metaphor 3.68	3.75	3.70	3.84	3.83
Tactile 3.93	Elegant 3.56				
Manual 3.91					
Eco-friendly 3.73					
Foldable 3.82					
Interaction 3.85					
Stackable 3.55					
Mean	Mean				
3.48	3.81				

TABLE 5 Basic demographics of student participants.

Attributes		Frequency	Proportion
Gender	Male	107	31.01%
	Female	238	68.99%
Education	Undergraduate	307	88.98%
	postgraduate	38	11.02%
Major	Visual communication design	178	51.59%
	Non-Visual Communication Design	167	48.41%
Years of design work	Less than 3 years	298	86.37%
	More than 3 years	47	13.63%

the results presented in Table 4. However, it should also be noted that participants might have been aware that the focus of the study was on creativity and thus tended to give more positive evaluations to these words. This may have influenced the distribution of responses.

4.3 Results of step three

In Experimental Step Three, data were analyzed using IBM SPSS version 25.0. Chi-square tests were applied to categorical variables with a two-tailed test, and the significance threshold was set at $p < 0.05$. Basic demographic information of the student participants in this test is shown in Table 5. A total of 409 questionnaires were distributed, and 345 valid responses were collected.

The chi-square test revealed no significant differences between practical experience and gender in relation to preferences for semantic

stimuli and creativity evaluation metrics ($p > 0.05$), indicating no correlation among these variables. However, four results were statistically significant:

4.3.1 Chi-square test result 1

As shown in Table 1, the two-tailed significance value between abstract and concrete semantic words ($p = 0.001$) is less than 0.05, indicating that these two types of semantic stimuli exhibit different triggering characteristics in guiding creative thinking. Combined with the overall performance of effectiveness scores, both abstract and concrete semantic types demonstrated strong potential in different task contexts, suggesting that while both are advantageous for stimulating creativity, they may do so through different mechanisms.

4.3.2 Chi-square test result 2

There is a significant correlation between the use of abstract semantic words and education level. As shown in Table 2,

TABLE 6 Chi-square test result of originality metrics vs. education level.

Test statistics	Value	Degree of freedom	Progressive significance
Pearson Chi-square	40.395	20	0.004
Likelihood ratio	36.657	20	0.013
Linear correlation	8.405	1	0.004
Number of valid cases	345		

TABLE 7 Chi-square test result of functional metrics vs. major.

Test statistics	Value	Degree of freedom	Progressive significance
Pearson Chi-square	38.499	23	0.023
Likelihood ratio	41.818	23	0.010
Linear correlation	8.400	1	0.004
Number of valid cases	345		

participants of different education levels exhibited significant differences in the use of abstract semantic words ($*p^* = 0.027 < 0.05$), indicating a correlation. This suggests that education level may influence preferences for semantic stimuli. Based on interview results and effectiveness scores, the postgraduate group was relatively more active in using abstract semantic words, demonstrating greater sensitivity and receptiveness to handling abstract concepts and conceptual generation.

4.3.3 Chi-square test result 3

A significant correlation also exists between the use of originality-related semantic words and education level. As shown in Table 6, students of different education levels showed significant differences in the use of originality-related semantic words ($*p^* = 0.004 < 0.05$). Combined with interview responses and effectiveness scores, the postgraduate group had a higher tendency to choose originality-related semantic words than undergraduates, suggesting that higher education levels may enhance individuals' originality tendencies in creative design. Considering the emphasis on innovative thinking in graduate education, it is speculated that postgraduate students may be more inclined to use originality-related semantic cues in the creative process compared to undergraduates.

4.3.4 Chi-square test result 4

There is also a significant correlation between the use of functional semantic words and participants' academic major. As shown in Table 7, students from different majors showed significant differences in their use of function-related semantic words ($*p^* = 0.023 < 0.05$), indicating a correlation. Interview responses and effectiveness ratings suggest that academic background may influence preferences for semantic stimuli. Given that functional design emphasizes practicality

and engineering thinking, students from non-visual communication majors such as product design, fashion design, and digital media may be more inclined to use function-related semantic words to align with their training, which prioritizes functionality and utility.

The chi-square test results indicate that there is a statistically significant correlation between the types of abstract and concrete semantic words and their effectiveness in stimulating creativity. Abstract semantic words may be more effective in terms of originality and aesthetics, whereas concrete semantic words may be more effective for structure and functionality.

These findings carry important implications for the refinement of teaching strategies in art and design education. First, the differentiated effects of abstract and concrete semantic stimuli highlight the need for educators to purposefully select stimulus types based on specific design tasks and learning objectives. For instance, when aiming to foster conceptual innovation and aesthetic exploration, abstract semantic words may serve as more effective early-stage triggers. In contrast, concrete stimuli may be better suited for tasks emphasizing structural problem-solving or functional detailing. Second, the confirmed influence of creativity evaluation orientations suggests that integrating evaluative language into the ideation phase—rather than reserving it solely for post-hoc assessment—can provide students with clearer mental frameworks for ideation. Finally, the observed differences across academic backgrounds indicate the importance of tailoring semantic prompts to match students' prior knowledge and cognitive preferences. In sum, the results offer actionable insights for aligning semantic stimulus design with pedagogical intent, potentially increasing the efficacy and inclusiveness of creativity instruction.

5 Discussion

Based on the above results, we have demonstrated the feasibility of using expert commentary words as semantic stimuli. Both abstract and concrete semantic words showed potential in stimulating creativity, with abstract words proving more promising than concrete ones. Abstract semantic words were more effective in stimulating originality and aesthetics, while concrete words were more suited to tasks emphasizing structure and functionality. We found that applying the tendencies of creativity evaluation indicators as semantic stimuli during the initial stages of design had a positive guiding effect on students' idea generation. Additionally, chi-square tests confirmed that individual differences such as participants' education level and professional background influenced their preferences for semantic stimuli and their creative performance.

A detailed discussion corresponding to the research questions is as follows:

Research Question 1: How do the sources and semantic types of stimuli inspire creativity in art and design education?

In the experiment involving students majoring in art and design, the use of expert commentary words as semantic stimuli shows promise as both feasible and effective. The quantitative results for semantic types revealed an insightful trend: regardless of whether the semantic words were abstract or concrete, their average usefulness scores were above the median, indicating that both types of semantic stimuli had a positive effect on promoting creativity. However, a

deeper comparison of their effectiveness in stimulating creativity revealed that abstract words were significantly more effective in enhancing students' creative performance, particularly in the dimensions of aesthetic perception and original expression. This may be related to the broader associative and conceptual transfer abilities evoked by abstract vocabulary. In contrast, concrete words were more helpful in supporting creative performance related to structural clarity and functional implementation, reflecting their role in aiding task clarity during actual design work. Thus, different types of semantic stimuli have distinct strengths in triggering specific dimensions of creativity, suggesting that in design education, semantic guidance strategies should be flexibly applied based on task requirements to maximize students' creative potential. Furthermore, qualitative interview results also revealed clear differences in how different types of words stimulated students' creative thinking. Abstract words such as "fusion" or "culture" tended to guide students toward conceptual construction and symbolic meaning, triggering philosophically and culturally imaginative creative responses. Concrete words such as "portable" or "material" more often evoked considerations of practical function, operability, and material use, stimulating a mindset focused on implementation and practicality. This phenomenon confirms Research Question 1: that different sources and types of semantic stimuli have a distinct impact on students' creativity in art and design education, with these effects exhibiting divergence in both levels and directions of thinking.

Research Question 2: How can the application dimensions of creativity evaluation indicators be expanded, and what is their impact on creative generation among design students?

Creativity evaluation indicators are traditionally used to assess the final outcomes of a completed design. However, in this study, we proposed using the tendencies of creativity indicators to classify expert commentary words and applying them as semantic stimuli during the early stages of idea generation. The study found that vocabulary related to the aesthetic and originality dimensions was significantly more effective than words related to structure and functionality. This reflects that creativity indicators are not only useful for later evaluation but can also serve as effective tools for guiding students' creative thinking from the beginning of the design process. Specifically, when students encountered symbolic and open-ended words like "magic" or "suggestion," their ideas tended to be more novel and diverse; when faced with concrete, function-oriented words like "logistics" or "preservation," students were more likely to generate highly operable and practical design solutions. These results support the core argument of Research Question 2: that introducing creativity indicator tendencies at the idea generation stage can positively influence design students' thinking and expression pathways, thereby expanding both the depth and breadth of their application in educational contexts.

Research Question 3: How do other participant factors (especially education level and professional background) influence the process of creative generation?

In exploring Research Question 3, results showed that participants' education level and professional background did indeed have an effect

on the creative generation process. Compared to undergraduates, graduate students were more inclined to select abstract semantic words during the early stages of idea development, especially showing stronger abstract thinking and symbolic association in the conceptual divergence phase. This difference may be attributed to their richer knowledge structures and more advanced cognitive training. At the same time, professional background also exhibited differentiated trends: students from non-visual communication design fields showed greater emphasis on functional and structural dimensions in their word choices, suggesting that different professional training shapes the focus of design attention. These findings collectively confirm Research Question 3—that individual background factors such as education and major exert a positive moderating and guiding influence on the paths and preferences of idea generation. This indicates that design education should adopt differentiated instruction approaches, paying close attention to background differences among students in order to better support their creative development.

In summary, the findings from the three research questions offer valuable insights into the use of semantic stimulation strategies within design education and practice. Specifically, the differentiated functions of abstract and concrete semantic words in the creative process can inform the phased structuring of teaching. For instance, in heuristic learning scenarios such as creative workshops, the introduction of abstract words like "fusion" can effectively spark innovative thinking and conceptual divergence among students. In contrast, during prototyping and testing stages, the use of concrete terms such as "durable" can help students focus on details and feasibility, strengthening their practical design execution. This semantic stratification is also applicable in professional practice settings. Project teams focused on sustainability can stimulate systemic and forward-thinking design ideas using abstract words like "renewability." Conversely, product development teams that prioritize functionality can benefit from concrete terms like "adjustable," which enhance the precision and efficiency of functional design.

Based on the analysis of participant characteristics, the study further proposes tiered teaching strategies using semantic stimulation. For undergraduate students, it is advisable to prioritize concrete and specific semantic stimuli during brainstorming and conceptual development stages to help build clear design frameworks and execution plans. For graduate students, abstract and conceptual stimuli can be introduced during later stages such as prototyping and iteration to enhance critical thinking and imaginative expression. This pedagogical approach, grounded in differences in cognitive development and learning stages, helps improve the adaptability and specificity of design education.

In addition, to better balance universality and individual differences, the study recommends a hybrid approach to semantic stimulation. On the one hand, general semantic cues can be used to broaden students' creative thinking boundaries; on the other, personalized and differentiated strategies can gradually be introduced to increase the contextual relevance and learning effectiveness of the stimuli. However, it's important to note that excessive customization might reduce students' adaptability to diverse design tasks. Therefore, an appropriate balance between guidance and openness should be sought to cultivate creativity with both depth and flexibility.

Moreover, drawing from recent studies on creativity (e.g., [Sandhu and Sarkar, 2025](#); [Wang and Han, 2023](#)), future pedagogical models

might consider integrating a combinatory use of semantic stimuli tailored to individual learners' cognitive styles and disciplinary needs. While this study focused on verbal semantic stimuli, especially semantic words, other formats such as visual metaphors, ambient soundscapes, or narrative memory cues may activate complementary aspects of creativity (e.g., intuitive, emotional, or associative thinking). A combinatory use of semantic stimuli may therefore enhance inclusivity and responsiveness in design education, offering differentiated entry points for diverse learners. This direction warrants systematic investigation in future work.

6 Conclusion

This study aimed to explore how semantic words can stimulate creative thinking in design students at the early stages of the design process.

The key innovations of the research lie in two aspects: first, the introduction of expert commentary words as semantic stimulation materials, verifying their specificity and effectiveness in educational contexts; and second, unlike traditional uses of creativity evaluation indicators at the end of the design process, this study innovatively frontloads these indicators by categorizing expert commentary words and transforming them into semantic stimuli to influence students' conceptual development pathways from the outset.

We examined the distinct impacts of abstract and concrete semantic words on creative thinking. Results showed that both types can effectively stimulate student creativity. Abstract semantic words were significantly associated with aesthetics and originality, while concrete semantic words were more aligned with structurally and functionally driven creative expression. By combining qualitative and quantitative methods and applying chi-square tests, we comprehensively assessed semantic types, creativity indicator tendencies, and individual participant differences. The study further revealed a significant correlation between abstract/originality-related words and education level—graduate students were more inclined to use abstract words and valued originality more than undergraduates. On the other hand, function-oriented semantic stimuli were more strongly preferred by students from non-visual communication design fields (such as product design, fashion design, and digital media), indicating a link between professional background and semantic preference in creative thinking.

In terms of educational impact, this study contributes to a shift in design teaching from a traditionally experience-based model to an empirically grounded, rationally guided approach. By introducing customizable semantic stimuli, educators are better equipped to target and stimulate students' creative thinking, improving both the adaptability and effectiveness of instruction. For design practice, the study provides a scientific foundation for the conceptual generation phase, helping design teams overcome cognitive inertia, improve efficiency, and accelerate the transformation of ideas into outcomes.

Theoretically, this study offers a new explanatory framework for understanding the mechanisms that stimulate creative thinking in design education and fills a gap in existing literature regarding the role of semantic stimulation in the early stages of

design. Practically, it provides systematic cognitive support tools for educators and design teams during the concept development stage.

However, there are certain potential limitations to this study. The sample size and representativeness are limited, which may affect the generalizability of the findings. Future research should expand the sample size and diversify participant backgrounds to enhance external validity and practical relevance.

Further research could also explore the integration of semantic stimulation tools with intelligent and digital design education platforms, aiming to construct a structured analytical framework for assessing the cognitive effects of semantic stimuli. Through online courses and interactive modules, it would be possible to deliver dynamic and personalized learning experiences. This approach would strengthen feedback mechanisms in design education, enabling real-time support at every stage of the creative process. Additionally, future studies could investigate the effectiveness of semantic stimulation across various design disciplines and explore whether mediating variables—such as design experience or cultural background—moderate the relationship between semantic stimuli and creative thinking.

In conclusion, this study systematically explored the role of semantic stimulation in enhancing creativity in art and design education, offering new theoretical support and practical value for both design education and professional practice.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Dalian Polytechnic University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

YY: Writing – original draft, Funding acquisition, Visualization, Resources, Formal analysis, Methodology, Conceptualization, Validation, Writing – review & editing, Investigation. YN: Writing – review & editing, Supervision, Project administration.

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