ONLINE COLLABORATIVE SKETCH-STORMING APPROACH IN CONTEMPORARY TEXTILE DESIGN MOTIF DEVELOPMENT

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(Received 21st March 2025; revised 04th June 2025; accepted 12th June 2025)

Abstract. The practice of textile design mostly depends on personal sketches, which produces repetitive motif variations instead of new creative ideas. Researcher explored the effectiveness of sketch-storming activities conducted online for developing creative textile motifs. The experimental session assembled 60 textile design students to carry out virtual sketch collaboration with digital software. Researchers analyzed the motifs through both qualitative and quantitative assessments based on their quantity and variety as well as novelty. Online collaborative sketching produces better creative results because it generates more original unique motifs than working individually on sketches. Students confirmed that working together in this environment triggered creativity because it fostered both shared inspirations along with continuous exchange of innovative ideas. The research demonstrated that live collaborative work combined with software version management and quick operational tools creates the perfect conditions for enhancing creative work. The study highlights important features which boost creative performances through real-time evaluation feedback as well as the opportunity to take risks and utilize iterative designing systems. Research findings demonstrate that educational and industrial applications of online sketching collaboration mechanisms will fuel disruptive motif development. This research enriches the digital ideation tool investigation by showing their capacity to advance creative result production while revolutionizing the textile industry design methods.
Keywords: *online collaborative, ideation, team creativity, creative tools, textile design*

Introduction

Sketching and identifying concepts through digital tools have transformed creative design work across fields such as industrial design, architecture, graphic design, and animation. Digital sketching and ideation techniques use digital tablets and software tools to make interactive creation possible through improved design freedom for visual concept development. Digital design tools enable designers to work in real time while permitting instantaneous tests of colors, textures, patterns, and successive development of concepts. Digital sketching and ideation tools present learning barriers to users while reducing their ability to feel physical touch during work. Textile design evaluation requires a thorough assessment of patterns, textures, and color evaluation, which highlights these limitations the most. Modern online collaborative tools enable visual sketch-storming as a collaborative method, which entails fast sketching while developing ideas together between multiple participants. Research shows that sketch-storming is an effective method for promoting innovative creativity in several design fields, such as product design, fashion, and architecture. Recent studies show that digital collaboration tools are transforming creative design processes. These web-based

platforms provide accessible alternatives to traditional brainstorming methods, enabling teams to combine diverse perspectives during creative development. The interactive nature of these tools supports iterative idea generation, allowing for more dynamic exploration of design solutions through visual collaboration.

Additional research must occur before determining how virtual collaborative sketching methods can work with all aspects of design practice. The research investigates how online sketch-storming applications support modern textile design by advancing design motifs. A research study was established on the premise that textile design creativity and innovation excel through virtual collaboration since it promotes joint idea generation and continuous visual concept development. This research investigates these tools to generate necessary knowledge about optimizing digital sketching and ideation for collaborative textile design, which leads to improved innovative seasonal designs. The creation of new fabric design patterns requires individual creativity and innovation. On the other hand, motif concepts practiced by designers are also likely bound by the individual sketching techniques explored (Cusano and Napoletano, 2017). The researchers have evidence that the designers working in isolation are more likely to design patterns based on other patterns and rarely go beyond the confined motifs. A condensed thought process of knowledge that is limited in scope and fails to display fresh ways of thinking is required to develop new ways of art. According to the latest research studies, collaborative sketchstorming can overcome these hindrances. During collaborative sketching, designers respond to each other's ideas and rapidly build on top of these ideas to explore a more extensive solution space (Joundi et al., 2020). Research shows that textile designers create more authentic motifs when they brainstorm collectively using sketching over individual idea generation. The interactions that resonate with revolutionary conceptual leaps include mutually inspiring creativity.

Nevertheless, the fundamental query left out is how to maximize collaborative sketch-storming for best motif innovation. However, factors such as group size, digital vs. analog sketching, and facilitation methods still need to be addressed in more detail (Cusano and Napoletano, 2017). In this regard, it is necessary to continue the research of translating collaborative sketch-storming creativity into implemented motif designs. Individual sketching limits the variety of textile design motifs, but group work on the development of sketches is prospective from the point of view of radical conceptual jumps. Further studies are required to identify the optimal collaborative sketching methods to achieve the highest motif innovation in current textile design.

Literature review

One of the most attractive methods of using design ideation for effective collaboration is online collaborative sketch-storming, which combines the advantages of brainstorming and sketching in a virtual space. Several studies have investigated the application use of online collaborative drawing tools in supporting product development by design teams (Lee, 2020). The studies were conducted to understand what the needs of design team members are, ideating new products over a computer network, and making sketches together, and these insights can guide towards the development of new tools for design ideation. Other studies have been conducted to determine the influence of different ideation techniques that have been subjected to creativity, such as sketching, brainstorming, and prototyping (Dam and Siang, 2019; Dorta et al., 2009). The mentioned studies have demonstrated that sketching can be an effective method for

expanding the design point of view, generating a vast number of ideas and discussions about sketches with other people. Nevertheless, research about the effectiveness of collaborative sketch-storming has not been performed, and there is no information about how this technique compares to other ideation methods. A recent system review of virtual reality for creativity from the perspective of fostering creativity was carried out to offer creators affordance and frame to combine VR into a brainstorming process that potentially increases creativity (Cusano and Napoletano, 2017).

Other studies have been conducted to determine the influence of different ideation techniques that have been subjected to creativity, such as sketching, brainstorming, and prototyping (Dam and Siang, 2019; Dorta et al., 2009). The mentioned studies have demonstrated that sketching can be an effective method for expanding the design point of view, generating a vast number of ideas and discussions about sketches with other people. Nevertheless, research about the effectiveness of collaborative sketch-storming has not been performed, and there is no information about how this technique compares to other ideation methods. A recent system review of virtual reality for creativity from the perspective of fostering creativity was carried out to offer creators affordance and frame to combine VR into a brainstorming process that potentially increases creativity (Cusano and Napoletano, 2017).

Collaborative sketching in design

The design ideation process uses visual communication through collaborative sketching, allowing various stakeholders to express their concepts and ideas through traditional drawings. The practice generates new creative ideas and establishes team mental models in architecture and product design as well as fashion applications (Velloso et al., 2023; Elsen et al., 2012). The combination of collaborative sketching helps engineers generate novel ideas and creates superior design outcomes through enhanced participant understanding according to Chandrasegaran et al. (2014). According to Abd Manan and Kennedy (2022) and Soygenis et al. (2010) sketches constitute a fundamental communication tool for architects to present complex ideas effectively. Sketches in product design play a vital role during different development phases because they help improve concept presentation and user feedback engagement (Nghiem et al., 2024). The integration of visual practices in textile design collaborative sketching requires further exploration because its research remains limited as compared to other design disciplines (Velloso et al., 2023; Chandrasegaran et al., 2014). Improving the methods and tools for collaborative sketching in textile design would generate better approaches that enhance design concept development within every field.

Technology and tools for collaborative sketching

Research about collaborative sketching tools demonstrates both positive and problematic outcomes specifically when applying them to textile design work. Digital platforms support collaboration through real-time communication and visual idea exchange, and these features align with textile designer needs since they depend on visual communication to present their ideas (Pfister and Eppler, 2012). The current tools face difficulties when utilized during the initial design phase because sketching proves most effective in this stage (handrasegaran et al., 2014; Daiber et al., 2012). The collaborative tools Wiki and interactive whiteboards do not successfully resolve the problems with remote communication that stem from missing social cues according to

Lee et al. (2020) and Jordan et al. (2015). The research lacks investigation into combining sketching functionality with modern mobile technologies for textile design purposes (Daiber et al., 2012). Designers must conduct additional studies to solve sketching tools' issues, which limit their functionality in various textile design environments, despite their potential for better creativity and communication.

User experience and interaction

The critical elements in collaborative sketching tools receive their power from UX/UI design which optimizes user experience and creative output. Studies show feedback mechanisms boost creativity through their ability to support creativity performance since Li et al. (2024) as well as Wu and Koutstaal (2022) provided evidence about this relationship. Wu et al. demonstrate how social learning feedback enhances creativity which proves that collaborative tools require both interaction and feedback (Wu and Koutstaal, 2022). According to Liu et al. feedback valence matters since teams are affected by both constructive and critical feedback (Liu and Wu, 2022). The precise elements of UX/UI design which optimize feedback mechanisms in collaborative sketching tools require further research. Research has described the way feedback affects creativity, but it lacks extensive analysis about how varying interface styles affect the effectiveness of feedback sharing (Gong et al., 2013; Weibel et al., 2010). Scarce research exists about how feedback mechanisms work with user engagement dynamics within collaborative settings and especially within digital sketching environments (Corneli and Jordanous, 2015; Hosseini et al., 2015). New design approaches that integrate improved interactive methods between users will emerge after resolving the current knowledge voids.

Collaborative sketching in textile design

Research on collaborative sketching in textile design has become important, but researchers still need to uncover all its potential applications. According to research, collaborative sketching helps designers enhance their design process through improvements in communication and joint idea creation (Härkki et al., 2018). The habit of people redirecting their sketches instead of developing others' ideas creates an impairment in collaborative effectiveness that damages teamwork advantages (Härkki et al., 2018). The textile industry restricts interdisciplinary collaboration because it applies a restricted definition of design which excludes important contributors including technicians (Coulter, 2018; Eckert, 2018). The separation between design and technology hampers exploration of collaborative sketch-storming for motif development because this method holds potential to create innovative and sustainable textile designs (Jimenez Moreno, 2022). The textile industry needs improved inclusive practices to utilize participatory design strategies because these methods remain underutilized for design process stakeholder involvement (Heimdal and Rosenqvist, 2012; 2010). Strategies to address these gaps would enhance both sketching collaboration within textile design and its associated outcomes.

Gaps in the study

Online collaborative sketch-storming presents itself as an appealing design ideation method because it combines the virtual space benefits of brainstorming and sketching to advance creative group collaboration among design teams. The literature explores

product development online drawing tools, sketching, and prototyping techniques for creativity, but fails to understand the relationship between sketch-storming methods and alternative approaches. The research shortage is particularly pronounced in textile design because studies regarding visual communication during collaborative sketching operations are rare. Virtual communication tools help quick data transmission, yet they do not solve technical restrictions or address social communication gaps when starting projects. Research has proved that UX/UI design feedback mechanisms enhance creativity, yet scientists have not examined enough how different interfaces impact user engagement when sharing feedback within digital sketch environments. The complete potential of collaborative sketch-storming remains limited in textile industries because of the existing interdisciplinary barriers which call for inclusive practices involving diverse stakeholders. Additional research must focus on developing better tools with guidelines and strategies to enhance effective use of sketch-storming in creative design practice across all fields.

Materials and Methods

An investigation utilized a mixed methods framework to determine how well online collaborative sketch-storming functions in designing new concepts. Complex research gets its optimal solution through the sequential exploratory design because its qualitative initial phase assesses contextual factors to guide the quantitative subsequent phase. A survey instrument designed through this method achieves higher validity and realism in its measurements. The sequential research design helps researchers develop their work through repeated cycles because it lets qualitative results lead quantitative investigations instead of collecting data at once as concurrent triangulation requires. The intentional ordering of qualitative then quantitative data collection methods proves vital since it boosts research validity together with promoting an enhanced unified knowledge base for the research subject matter. Qualitative data gathering and analysis were necessary in the first phase of the research design. Semi-structured interviews were administered on purposively recruited participants involved in online collaborative sketch-storming for design ideation. All the interviews were taped and transcribed, and the data were analyzed using qualitative methods such as coding, theme identification, and interpretation. As a result of the findings from the qualitative part of the study, the researcher conducted an interim analysis to find the emerging patterns and themes and possible quantitative analysis areas. These findings guided the construction of a Novelty Level Scoring Rubric tool so that the quantitative phase was not only based on but directed by the qualitative results.

In the next phase, the researcher provided the Novelty Level Scoring Rubric out for two coders by utilizing a five-points assessment rubric for textile motif ideas; Minimal Novelty (1), Low Novelty (2), Moderate Novelty (3), High Novelty (4) and Exceptional Novelty (5) (*Table 1*). This phase sought to quantify data concerning the themes and patterns that emanated from the qualitative analysis to ensure that statistics could be used to analyze results and generalize findings. The evaluation of original textile motif ideas used a modified version of the established creativity assessment techniques (Runco and Jaeger, 2012; Amabile, 1982; Besemer and Treffinger, 1981) scored on a 5-point scale. The established creativity assessment frameworks stress novelty as a principal factor of creativity, which defines newness as the extent to which ideas or products diverge from standard available solutions. The evaluation process of

originality employs expert judgment according to Amabile's consensual assessment technique but utilizes Besemer and Treffinger's criteria for creative products to offer structured assessment of novelty. The analysis between Runco and Jaeger strengthens the concept of originality in creativity, which matches the evolutionary steps of minimal to exceptional novelty in the rubric. The theoretical foundation provides a solid basis for measuring originality of textile motifs while using this method in the current study.

Table 1. *Novelty level scoring table.*

Score	Novelty level	Description
1	Minimal Novelty	The motif is highly conventional, lacks originality, and closely resembles existing designs.
2	Low Novelty	The motif shows slight variations from traditional designs but lacks distinctive or innovative elements.
3	Moderate Novelty	The motif balances conventional and creative elements, with some unique features or reinterpretations.
4	High Novelty	The motif is largely original, with distinctive elements, creative combinations, or unconventional approaches.
5	Exceptional Novelty	The motif is groundbreaking, featuring unique elements, bold reinterpretations, or innovative concepts.

Source: Amabile (1982).

The quantitative data gathered were appropriately analyzed using basic and advanced statistical analysis such as descriptive statistics, inferential statistics (means, standard deviations, sample sizes, t-values, p-values), and other related tests. These analyses gave quantitative information on the associations, directions, and regularities established in the data. After analyzing both qualitative and quantitative data, the researcher combined the findings from the two phases of the research study. This integration included seeking points of similarity and difference and even points of enlightened contrast, which, in effect, enriched one's understanding of the phenomenon of study. The results of integrating the findings were discussed, as well as the research questions and the literature. The researcher presented a critique of the findings concerning the contribution to theory, applied values, constraints, and suggestions for further studies. Finally, this research adopted a sequential exploratory mixed-methods design to capture the advantages of the two paradigms while ensuring that the study delved deeper into the effectiveness of online collaborative sketch-storming in design ideation processes. The systematic incorporation of these complementary methods supported the research's methodological quality, internal and external validity, and generalisability.

The population of interest in this research study was the target population of students working in collaborative design in virtual environments. More specifically, the target population consisted of students with a hard-wired appreciation and working experience of such collaborative design processes through online sketch-storming. Due to the above population characteristics, the intentional sampling method, purposive sampling, was used to arrive at a sample population. It is a non-probability sampling technique whereby participants were chosen purposefully concerning certain characteristics considered important for the study by the researcher. The sample of this specific research was selected from a group of final-year students in an academic course in textile design. The subjects were 60 students in two groups, including 30 individuals. The first group comprised students in the middle of their studies in the program, those in their fifth semester, while the second group comprised students in their last semester of

the program, the sixth semester. The premise of this classification was to get views from learners at various class levels to include the effects of their experiences and exposure to collaborative design in virtual environments. One of the strict requirements for sample selection was the participants' previous engagement in similar co-design processes in digital environments. This criterion allowed participants with prior exposure to the research variables and adequate experience to provide relevant data to the research question (Cardoso et al., 2016). By intentionally sampling and consciously gaining participants from academic performance, semester progress, and experience, the researchers endeavored to get a sample that would afford profoundly situative data to meet the research objectives.

Results and Discussion

How Do the Quantity and Novelty of Textile Motif Concepts Generated Through Online Collaborative Sketch-Storming Differ from Individual Sketching Approaches? The research data shows collaborative sketching exceeds individual sketching by producing more diverse textile motifs which are also greater in number. Participating groups in collaborative sketching created an average of 35.2 motif ideas (SD=8.1) which exceeded the average motif production (12.4) among individual sketchers (SD=3.2). A highly significant difference emerged between the two groups based on results from the independent samples t-test ($t(58)=11.24$, $p<.001$, $d=1.72$) and indicated a large effect size. Participants who share an ideation space achieve higher numbers of discrete motifs through the combination of idea exchange and interactive feedback during real-time collaborative work. Group members who motivate each other lead to increased output through social facilitation. Group sketching pushes individuals past cognitive limitations that would otherwise limit their original ideas by introducing outside stimulation during the creative process (*Table 2*).

Table 2. *Descriptive comparison between collaborative and individual sketching.*

Variable	Collaborative sketching	Individual sketching
Sample Size	n = 30	n = 30
Time Given	30 minutes	30 minutes
Measurement of Quantity	Total number of discrete motif ideas	Total number of discrete motif ideas
Measurement of Novelty	5-point rubric by two coders ($\kappa = 0.82$)	5-point rubric by two coders ($\kappa = 0.82$)
Quantity Results	M = 35.2, SD = 8.1	M = 12.4, SD = 3.2
Novelty Results	M = 3.8, SD = 0.6	M = 2.9, SD = 0.4
Quantity Test	$t(58) = 11.24$, $p < .001$, $d = 1.72$	-
Novelty Test	$t(58) = -6.33$, $p < .001$, $d = 1.51$	-

The creativity scores for collaborative sketching methods exceeded those of individual sketching methods with M=3.8 (SD=0.6) compared to M=2.9 (SD=0.4). This difference was assessed through a five-point rubric with strong inter-rater reliability ($\kappa=0.82$). The analysis demonstrates a significant large effect through $t(58)=-6.33$, $p<.001$, $d=1.51$, which shows the meaningful novelty distinction between both conditions. Real-time collaborative interactions between participants lead to an increase in novelty through the combination of divergent thinking and risk-taking behavior because participants encounter multiple artistic viewpoints while developing new ideas together. The feedback nature of collaborative work seems to enhance motif design development through innovative pathways. Participants who worked individually on sketches seemed to favour established patterns from their cognitive schemas, which restricted their motif creativity. The research indicates collaborative digital

environments create an ideal environment for both innovative idea generation and creative exploration, thus they prove perfect for textile design innovation.

What Features of Online Sketch-storming And Digital Sketching Tools Most Enhance Creative Flow During Collaborative Sketching for Textile Motifs? Three sessions of focus groups with ten participants each were conducted with collaborative sketching participants. Transcripts were analyzed using thematic analysis (open and axial coding) to identify main themes, sub-themes with the participant quotes, and lastly the researcher's interpretation from the constructs. Five significant features of the online sketch-storming tools were found to enhance creative flow (*Table 3*).

***Table 3**. Thematic analysis for online sketch-storming.*

Main theme	Sub-theme	Interpretation	Participant quotes
Collaborative Dynamics	Real-Time Co-Creation	Participants valued the ability to work simultaneously, fostering a sense of teamwork and shared creativity.	P9: "It felt like we were all in the same room, even though we were miles apart."
	Idea Building	The back-and-forth exchange of ideas allowed for rapid iteration and refinement.	P3: "We could riff off each other's ideas instantly, it was like a creative ping-pong."
Design Iteration	Version Control	Automatic saving of versions enabled participants to revisit and build on past work.	P5: "I could pull up an old design and tweak it without losing the original."
	Comparative Analysis	Side-by-side comparison of versions helped in evaluating progress and making decisions.	P2: "Seeing the variations together made it easier to choose the best direction."
Tool Efficiency	Custom Brushes	Tailored digital tools streamlined the design process, overcoming physical media limitations.	P7: "The pattern fill brush saved me hours I could experiment freely without redoing work."
	Mirroring Effects	Symmetrical design features allowed for quick visualization of complex patterns.	P4: "The mirroring tool made it so easy to create balanced, intricate designs."
Creative Freedom	Risk-Taking	The safety net of version history encouraged participants to experiment boldly.	P6: "I wasn't afraid to try something wild because I knew I could always go back."
	Exploration	Participants felt empowered to explore unconventional ideas without constraints.	P8: "The tools let me push boundaries I wouldn't have dared to with traditional methods."
Emotional Engagement	Excitement	Real-time collaboration and efficient tools created a sense of excitement and energy.	P1: "It was exhilarating to see the design evolve in real time with everyone's input."
	Satisfaction	Participants expressed satisfaction with the ease and quality of the final output.	P10: "I felt proud of what we created-it was seamless and polished, thanks to the tools."

The thematic analysis table shows what participants felt regarding their encounters with digital collaborative design tools. The analysis identifies the main advantages alongside emotional outcomes that stem from using such digital tools, which centre on increased efficiency alongside creativity and user engagement. The analysis showed that Collaborative Dynamics functioned as a vital topic because it showed how real-time co-creation and idea-building serve important purposes. The simultaneous work capability of participants led to increased teamwork because it enhanced shared creativity. The continuous exchange of design ideas led to quick refinement just like a "creative ping-pong" system. The research indicates that digital collaborative platforms develop open platforms which mirror physical co-working areas. Version control together with comparative analysis stand as vital elements within the creative process according to Design Iteration. Participants could freely experiment through automatic saving functions because the functions protected work from accidental loss. The ability to view

two designs simultaneously allowed users to make sound decisions based on their work progression and choose optimal design directions. Digital tools create better conditions for flexible design improvements through more efficient design methods.

Digital tools achieve Tool Efficiency by providing users with features for customized brushes as well as mirror effects capabilities. The participants discovered that digital features optimized their workflow operations by transcending limitations which traditional media methods presented. Illuminating effects let users make complex symmetrical designs with enhanced speed by cutting down the amount of physical labour required. The use of specialized digital tools produces precise outcomes coupled with increased design production. The essential theme of Creative Freedom enabled digital tools to stimulate risk-taking along with exploratory activities. Version history provided designers with a safety system that enabled them to experiment with bold ideas. The absence of creative limitations allowed test subjects to build their confidence and develop innovation skills. The last theme Emotional Engagement describes the participants' overall satisfaction and excitement regarding their digital design experience. Participants gained enthusiasm from real-time collaboration alongside the achievement of both high quality and efficient final work, which brought pride. The research highlights digital collaborative tools as an efficient interactive system which enhances creativity for professional designers. As the limitations, two main constraints in the study reduce its broader reliability and applicability even though statistical significance exists. The study utilizes a limited participant group with 30 people conducting collaborative sketching and another 30 performing individual sketching, which hinders the ability to generalize findings beyond their sample demographic. The subjective assessment of novelty faces challenges because the inter-rater reliability measures (κ=0.82) fail to eliminate coder subjectivity when observing creativity assessment. The study challenges interpretation validity because future research needs to increase participant numbers while developing standardized creativity assessment protocols for design evaluations.

The participants in the online collaborative sketch-storming study encountered multiple obstacles that affected their creative workflow because of coordination problems, along with digital tiredness and accessibility limitations. The variety of design approaches together with different artistic speeds and random motif misalignments fragmented the overall idea development process. With specific facilitation strategies including organized brainstorm sessions and predetermined themes alongside specific participation roles, deadlock situations will become easier to resolve. Digital fatigue developed into a challenge because long screen usage combined with continuous visual stimulation and mental exhaustion caused attention difficulties and creativity-related exhaustion. Breaking work periods and switching roles together with offline drawing features that combine with digital tools will help users stay focused while reducing their fatigue. The participants faced different accessibility challenges because they had restricted access to technology devices and software, and variations in digital skill levels, which produced disparities in their work outputs. To overcome these barriers, organizations must implement digital tools that work for all users and need basic system specifications, as well as conduct complete training sessions and enable offline access to reach users with limited internet access. The implementation of these strategic solutions will make collaborative sketch-storming into an inclusive method which promotes efficiency and sustainability in textile design innovation. The research design incorporated data triangulation techniques to boost research validity through the

combination of qualitative methods and quantitative motif assessments together with statistical results. The research employed a combined approach that utilized interviews to identify important themes about collaborative systems, which were assessed through quantitative measurement using the Novelty Level Scoring Rubric. The data showed that collaborative sketching generated motif novelty scores which were statistically superior compared to individual sketching ($M=3.8$, $SD=0.6$ vs $M=2.9$, $SD=0.4$) with a significant effect of $t(58)=-6.33$, $p<.001$, $d=1.51$. These findings were endorsed by thematic analysis as study participants reported that working with others generated innovative ideas that matched statistical data demonstrating increased output and novelty. Stroke participants noted feelings of digital fatigue, yet the numerical findings from the survey did not reveal substantial decreases in efficiency, thus showing a perception versus empirical effect. The use of multiple research methods in this study has confirmed that digital collaborative sketch-storming produces effective outcomes for textile motif creativity.

Conclusion

Online collaborative sketch-storming allowed designers to collaborate visually for idea development, they did with real-time interaction across distant locations. The research shows how digital sketching platforms build teamwork better than face-to-face meetings while delivering enhanced creativity and innovation as their main advantage. Digital collaboration tools have demonstrated their crucial value for design practices today because they solve team obstacles while producing innovative ideas and speeding up design workflows in textile design, architecture, and fashion design, and beyond. The emerging technology of virtual reality (VR) represents a promising future possibility to boost the innovative capabilities of these platforms by enabling virtual interactive and immersive design sessions. The development of user-friendly interfaces together with consistent device support needs immediate attention to enable designers of any experience level access to these tools. The complete implementation of these findings demands an investigation into their application scope between various design practices across different contexts to achieve maximal effectiveness. The research demonstrates the need for organizations to use online sketching tools in their design processes to boost creativity along with productivity. Design teams should utilize real-time co-creation with version history together with domain-specific tools for simultaneous innovation and improved team partnerships through their system. Educational institutions along with business leaders should integrate these platforms into their educational curriculum to train new designers who will thrive in digital creative environments. The evolution of design ideation includes online collaborative sketching, which presents scalable effective solutions for creative collaborative work. These technology tools will become essential design drivers as they advance toward forming an international community of people who break existing boundaries in design innovation.

Acknowledgement

The research is self-funded. No acknowledgement to anyone is necessary.

Conflict of interest

The authors confirm that there is no conflict of interest involved with any parties in this research study.

REFERENCES

[1] Abd Manan, M.S., Kennedy, B. (2022): Exploring sketches as conceptual data: a semiological experiment on moods visualisation among architectural students. – Archnet-IJAR: International Journal of Architectural Research 16(1): 203-221.
[2] Amabile, T.M. (1982): Social psychology of creativity: A consensual assessment technique. – Journal of Personality and Social Psychology 43(5): 997-1013.
[3] Besemer, S.P., Treffinger, D.J. (1981): Analysis of creative products: review and synthesis. – The Journal of Creative Behavior 15(3): 158-178.
[4] Cardoso, C., Badke-Schaub, P., Eris, O. (2016): Inflection moments in design discourse: How questions drive problem framing during idea generation. – Design Studies 46: 59-78.
[5] Chandrasegaran, S., Badam, S.K., Zhao, Z., Elmqvist, N., Kisselburgh, L., Ramani, K. (2014): Collaborative sketching with skWiki: a case study. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, American Society of Mechanical Engineers 46407: 10p.
[6] Corneli, J., Jordanous, A. (2015): Implementing feedback in creative systems: A workshop approach. – ArXiv Preprint 11p.
[7] Coulter, J. (2018): The designers leap: boundary jumping to foster interdisciplinarity between textile design and science. – Journal of Textile Design Research and Practice 6(2): 137-162.
[8] Cusano, C., Napoletano, P. (2017): Visual recognition of aircraft mechanical parts for smart maintenance. – Computers in Industry 86: 26-33.
[9] Daiber, F., Li, L., Krüger, A. (2012): Designing gestures for mobile 3D gaming. – In Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia 4p.
[10] Dam, R.F., Siang, T.Y. (2019): Introduction to the essential ideation techniques which are the heart of design thinking. – Interaction Design Foundation 1p.
[11] Dorta, T., Lesage, A., Pérez, E. (2009): Design tools and collaborative ideation. – Joining Languages, Cultures and Visions: CAADFutures 15p.
[12] Eckert, J. (2018): Leading the conversation-why design education should care more about leadership and stewardship in design. – Cumulus Paris 13p.
[13] Elsen, C., Demaret, J.N., Yang, M.C., Leclercq, P. (2012): Sketch-based interfaces for modeling and users' needs: Redefining connections. – AI EDAM 26(3): 281-301.
[14] Gong, Y., Kim, T.Y., Lee, D.R., Zhu, J. (2013): A multilevel model of team goal orientation, information exchange, and creativity. – Academy of Management Journal 56(3): 827-851.
[15] Härkki, T., Seitamaa-Hakkarainen, P., Hakkarainen, K. (2018): Line by line, part by part: collaborative sketching for designing. – International Journal of Technology and Design Education 28: 471-494.
[16] Heimdal, E., Rosenqvist, T. (2012): Three roles for textiles as tangible working materials in co-designprocesses. – CoDesign 8(2-3): 183-195.
[17] Heimdal, E., Rosenqvist, T. (2010): Textiles as tangible working materials in participatory design processes: potentials and challenges. – In Proceedings of the 11th Biennial Participatory Design Conference 4p.
[18] Hosseini, M., Shahri, A., Phalp, K., Taylor, J., Ali, R. (2015): Crowdsourcing: A taxonomy and systematic mapping study. – Computer Science Review 17: 43-69.

[19] Jimenez Moreno, E. (2022): Study of the possibilities of 3D-printing for Footwear design and development of models for this new market.: Studie av möjligheterna med 3D-printing för Skodesign och utveckling av modeller för denna nya marknad. – Joinkoping University 98p.
[20] Jordan, A., Selway, M., Grossmann, G., Mayer, W., Stumptner, M. (2015): Ontology-based process modelling for design. – In Design Computing and Cognition'14, Springer International Publishing 18p.
[21] Joundi, J., Christiaens, Y., Saldien, J., Conradie, P., De Marez, L. (2020): An explorative study towards using VR sketching as a tool for ideation and prototyping in product design. – In Proceedings of the Design Society: DESIGN Conference, Cambridge University Press 1: 225-234.
[22] Lee, M.H. (2020): User-adaptive data visualization in daily context through everyday objects. – Archives of Design Research 33(1): 5-15.
[23] Li, A., Lu, Y., Song, N., Zhang, S., Ma, L., Lan, Z. (2024): Understanding the Therapeutic Relationship between Counselors and Clients in Online Text-based Counseling using LLMs. – ArXiv Preprint 24p.
[24] Liu, C.Y., Wu, C.J. (2022): STEM without art: A ship without a sail. – Thinking Skills and Creativity 43: 12p.
[25] Nghiem, C.M.G., Bousseau, A., Sypesteyn, M., Hoftijzer, J., Tsandilas, T. (2024): Sketch Presentation for Product Design. – In Proceedings of the 35th International Francophone Conference on Human-Computer Interaction 4p.
[26] Pfister, R.A., Eppler, M.J. (2012): The benefits of sketching for knowledge management. – Journal of Knowledge Management 16(2): 372-382.
[27] Runco, M.A., Jaeger, G.J. (2012): The standard definition of creativity. – Creativity Research Journal 24(1): 92-96.
[28] Soygenis, S., Soygenis, M., Erktin, E. (2010): Writing as a tool in teaching sketching: Implications for architectural design education. – International Journal of Art & Design Education 29(3): 283-293.
[29] Velloso, L.M.R., de Carvalho, M.F., Araújo, G.M., Jarske, J.M., Garcia, L.A., de Souza, L.S., Ito, M., Alves-Souza, S.N., dos Santos, T.L., Fernandes, H.M., Filgueiras, L.V.L. (2023): Contributions of remote collaborative sketching to the design of infovis in public health. – InfoDesign-Journal of Information Design 20(1): 21p.
[30] Weibel, D., Wissmath, B., Mast, F.W. (2010): Immersion in mediated environments: The role of personality traits. – Cyberpsychology, Behavior, and Social Networking 13(3): 251-256.
[31] Wu, Y., Koutstaal, W. (2022): Creative flexibility and creative persistence: Evaluating the effects of instructed vs autonomous choices to shift vs. dwell on divergent and convergent thinking. – Consciousness and Cognition 105: 18p.