Towards a Creativity Support Tool for Facilitating Students' Creative Thinking on Writing Tasks

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Abstract: Creative thinking is one of the key skills of human intelligence that leads to the generation of valuable and novel ideas. It is also considered essential for developing students' capabilities and their cognition. While recent advances in artificial intelligence and machine learning technologies have been shown to promote critical thinking, learner interfaces that support the 'creative thinking' of students are scarce. In this work, we present a design system for facilitating students' creative writing abilities. We follow a learner-centered design methodology, and evaluate the design system functionally, visually, and for accessibility, with a group of twelve students as representative users. The results show that designing alongside the target audience helps to rapidly identify user needs, individual preferences, and diverse viewpoints, and shows that the designed system performs better in all tested aspects including learner satisfaction, ownership, and self-efficacy.

Keywords: Creative Thinking, Educational Technology, Adaptive Writing Support

1 Introduction

Creative thinking is an innate ability that is shown to have a positive influence on students' academic performances and their personal development. This way of thinking lets the student engage in a thought process that allows them to explore distinct ideas in an unconventional way. According to Torrance [To72], four main components are essential for creative behavior: fluency (the total number of relevant ideas generated); flexibility (the number of different categories of ideas); originality (the rarity of the ideas generated); and elaboration (the amount of detail in the ideas). In this rapidly evolving landscape of technology-enhanced learning, teaching methods have either been directly/indirectly adapted from conventional pedagogy into the technological pedagogical environment. In this transition, the importance to promote creative thinking skills has been disoriented. However, a few learner interfaces [WJL22, Fr19] retain the importance of promoting creative thinking skills in combination with other skills such as domain knowledge. However, previous research [Fr19] has shown us that transferring conventional methods into a technological environment does not render the same educational benefits. Especially, technological environments struggle, to react promptly to learners'

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interactions. Nevertheless, research efforts are currently taking place to understand the most-valued components in creativity support tools.

In this paper, we aim to address this gap, by designing a creativity support intervention together with students following a learner-centered design. We present a holistic design cycle including the design thinking methodologies used in our study. To this end, we first conducted design interviews with a representative population of students and set up two different design systems with the same functionalities but with a different user interface design (i.e. design components, informational components, and navigational components). We used the two design prototypes to conduct a within-subject experimental study, in which we investigated what influence they have on user experience, creative performance, and immersion.

2 Related Work

Recent research has shown to closely investigate the different aspects (such as user experience, immersion, and performance ratio) of digital technological environments [Pa22]. An experiment conducted by Palani et al. [Pa22] with creativity practitioners revealed that the most valued components of a creativity support tool (CST) are the CST's features and functionalities, performance, interface, and user experience. Furthermore, Hillmayr et al. [Hi20] highlights how digital tools could impact learning and how different methods of representation creates an educational impact. Several design principles and heuristics are followed in CST research showing the importance of building effective design solutions. Resnick et al. [Re05] proposed design principles that align with 'low thresholds, high ceilings, and wide walls'; support many paths and many styles; support collaboration; support open interchange; and make it as simple as possible and choosing the black boxes of explorability carefully. Shneiderman [Sh07] proposed similar design recommendations that focus on supporting exploration, and collaboration, and includes low thresholds, high ceiling, and wide walls. In a more recent work [WJL22], it is reported that technology-enhanced learning could benefit students' creativity positively. At the same time, the authors also point out that there have been no or few studies that explored the connection between technological capabilities and their impact on students' creativity, and learning performances [OH19]. These prior works led us to investigate different representations of creative writing support tools.

3 Design Process of the Creativity Support Tool for Writing

Following a learner-centered design process, we designed and implemented our adaptive support tool capable of supporting students' creative writing. We describe the design process involved.

(i) *Deriving Requirements from Literature.* We searched the literature in the field of educational technology (EdTech), human-computer interaction (HCI), and creativity-supporting nterventions. The keywords used were: creativity AND EdTech, creativity AND HCI, creativity AND support intervention. The initial search criteria led us to 123 papers from the following databases: Google Scholar, ACM digital library, ScienceDirect, and Elsevier, which were then filtered based on their relevance to our current research and their quality. During the final scan, we included 24 papers with the following inclusion criteria: papers that include (i) creativity theories, (ii) conventional methods for creativity assessment (e.g. creativity support index), (iii) design principles for creativity support tools, and (iv) successful implementations of learning support interventions. Further screening was conducted based on the relevance to education (educational tools), language (English), and accessibility (open access or accessible via institution). We then collected the literature issues and formed the basis for literature-driven design requirements (see figure 1) for our design system.

(ii) *Deriving Requirements from Representative Sample of Learners.* We followed a learner-centered design approach and conducted twelve semi-structured interviews with a representative sample of students (university students who could benefit from our educational tool) to obtain an initial understanding of the requirements. Each interview lasted for an average of 29.7 minutes (SD = 13.6 minutes) and consisted of 27 questions. The interviewees (Male=5; Female=7) were between the age group of 22 - 33 (M=24.9; SD=3.1) and studied linguistics, computer science, or engineering. 20 pre-determined questions were discussed with the students in a semi-structured manner, where we allowed students to express their opinions on technology-based learning systems, their perceptions of existing learning systems in use, and the importance of creative skills in university education. Following this, we included questions from the well-established technology acceptance model (TAM) [VB08] to further gain an understanding of the system needs (e.g. performance and technical needs) and system requirements (e.g. functional requirements, design requirements) for fostering creative writing. The interviews were recorded, manually transcribed by two coders, and were used for qualitative content analysis.

(iii) *Mapping User Stories into Design Principles.* From the transcribed data, we mapped each user requirement into user scenarios with the intention of converting users' descriptions into realistic situations relevant to the design of a solution. At the end of the mapping process, we derived 33 scenarios with different goals and objectives. The priority of each scenario was set based on the number of occurrences (i.e. the number of times different users mentioned the same scenario). At the end of the coding process, we derived 8 scenarios that were mentioned more than thrice. We aggregated the meta-/user-requirements (see figure 1) that were identified from the literature and user interviews. The aggregated requirements were then coded into six design principles, forming the basis for designing our creative writing-support tool.

(iv) *Prototyping.* Based on the derived design principles, we designed two low-fidelity prototypes of the creativity writing-support tool. We conducted a follow-up study with

university students (n=4) to test different design hypotheses and validate our design principles. For example, design principle one described that receiving feedback with highlighted parts of texts to show the strengths of the learner (highly creative parts), and weaknesses or inconsistencies (less creative parts) of the learner will help students identify creative parts of their writing. These design principles (see Figure 1) formed the basis for the design of our creative writing-support tool.

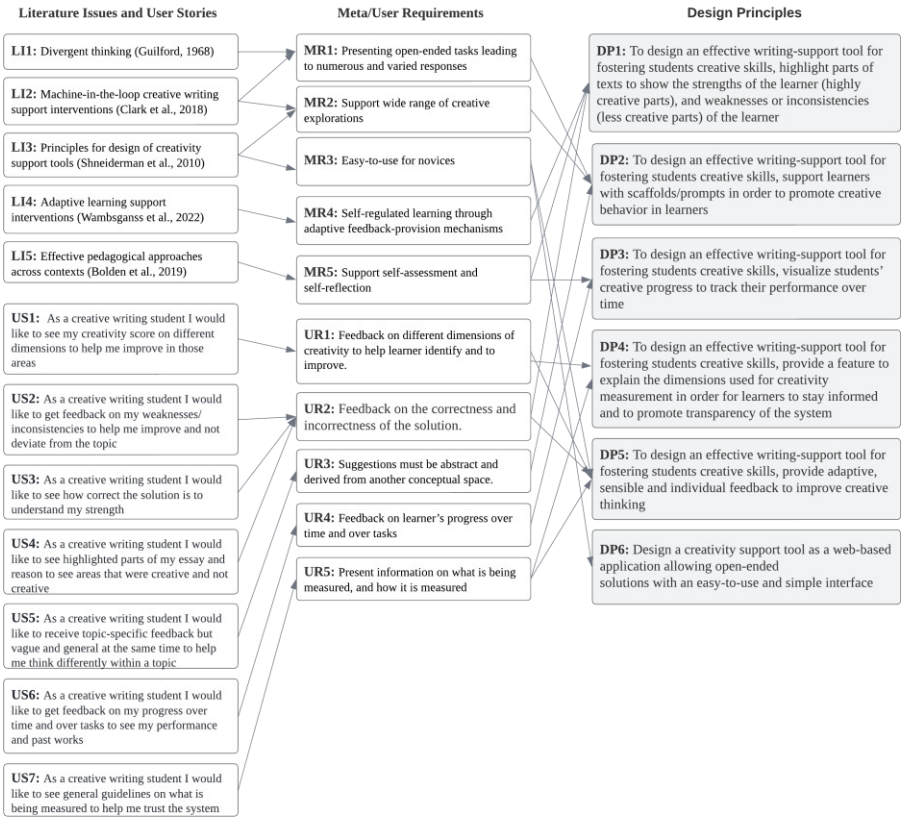

Fig 1: Overall design thinking process from gathering requirements to deriving design principles.

4 Results

User Interface Designing. Based on the design principles, we created paper prototypes and tested them with four representative students. We then validated and aggregated the design requirements and derived a final design prototype (see Figure 2). Our design system provides a simple user interface (DP6) with a simple text input field in which the students

are allowed to write, edit, or modify an essay. The user interface also allows students to navigate to the start page (where a description of the tool is provided), and an information page (where detailed information of the internal working of the design system is provided). The students are allowed to submit the essay at any stage in order to receive adaptive feedback throughout their writing process. The creativity learning dashboard provides individual feedback (DP1) by highlighting the strengths and weaknesses in the essay. Additionally, it analyzes the creativeness of an essay (DP3) based on three aspects [To72]: fluency (the ability of students to come up with varied ideas), flexibility (the ability of students to make novel connections between ideas), and originality (the ability of students to come up with unique and unexplored ideas). These three aspects are visualized through a progress indicator, below which a hover feature is provided to support transparency of the creativity measurement process (DP4). Further, the creativity learning dashboard provides a visualization of individual ideas extracted from the student's essay. In order to support design principle two, the tool provides scaffolds of topics relevant to the student's essay (DP2) to invoke new connections in their essay. These design principles were integrated with prior design recommendations in mind [Cl18],[Sh07].

Fig. 2: Screenshot of an adaptive writing support tool for creativity (where DP stands for design principles). Left: A student writes an essay on a particular topic in the text editor and receives adaptive feedback on their creative level through a creativity learning dashboard. Right: Creativity learning dashboard provides scaffolds and guides students to write unexplored ideas in an essay.

5 Conclusion and Outlook

Designing intuitive learner interfaces can be challenging for educational technology developers. There are still open questions to address on the connection between technological design and capabilities, and its impact on students' creative performance and learning experiences [OH19]. In this work, we explored the potential of creative writing support and designed a learning tool considering learner-centered design methodologies, and existing design recommendations for addressing writing-related learning tasks. Our results from the prototype testing phase revealed that co-designing with students helps to rapidly improve the learning interface instantly based on their critical needs, preferences, and viewpoints. Despite the efforts to understand a new interface, the general conclusion from user testing is that the designed learning interface

is intuitive, and promotes learner satisfaction, ownership, and self-efficacy. In future work, we plan to investigate the effectiveness of the designed learner interface in real-time incorporating intelligent AI techniques to support creative behavior, alongside a baseline study interface as a between-subject study design. Furthermore, we plan to evaluate the creative performances of students using our creativity support tool, with students using the baseline method, in a longitudinal study. This work can serve as a useful guideline for educational technology practitioners to incorporate similar design aspects and features for creativity support tools in different educational domains.

Bibliography

[Cl18] Clark, E.; Ross, A.S.; Tan C.; Ji Y.; Smith N.A.: Creative Writing with a Machine in the Loop: Case Studies on Slogans and Stories. In: 23rd International Conference on Intelligent User Interfaces. IUI ’18, Association for Computing Machinery, New York, NY, USA, p. 329–340, 2018.

[Fr19] Frich, J.; MacDonald Vermeulen, L.; Remy, C.; Biskjaer, M. M.; Dalsgaard, P.: Mapping the Landscape of Creativity Support Tools in HCI. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. CHI ’19, Association for Computing Machinery, New York, NY, USA, p. 1–18, 2019.

[Hi20] Hillmayr, D.; Ziernwald, L.; Reinhold F.; Hofer S.I.; Reiss K.M.: The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis. Computers Education, 153:103897, 2020.

[OH19] Oppenlaender, J.; Hosio, S.: Design Recommendations for Augmenting Creative Tasks with Computational Priming. In: Proceedings of the 18th International Conference on Mobile and Ubiquitous Multimedia. MUM ’19, Association for Computing Machinery, New York, NY, USA, 2019.

[Pa22] Palani, S.; Ledo, D.; Fitzmaurice G.; Anderson F.: Ï Don’t Want to Feel like I’m Working in a 1960s Factory": The Practitioner Perspective on Creativity Support Tool Adoption. In: Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. CHI ’22, Association for Computing Machinery, New York, NY, USA, 2022.

[Re05] Resnick, M.; Myers, B.; Nakakoji K.; Shneiderman B.; Pausch R.; Selker T.; Eisenberg M.: Design Principles for Tools to Support Creative Thinking. Report of Workshop on Creativity Support Tools, 20, 2005.

[Sh07] Shneiderman, B.: Creativity Support Tools: Accelerating Discovery and Innovation. Communications of the ACM, 50(12):20–32, 2007.

[To72] Torrance, E Paul: Predictive validity of the Torrance tests of creative thinking. The Journal of creative behavior, 6(4):236–252, 1972.

[VB08] Venkatesh, V.; Bala, H.: Technology acceptance model 3 and a research agenda on interventions. Decision sciences, 39(2):273–315, 2008.

[WJL22] Wambsganss, T.; Janson, A.; Leimeister J.M.: Enhancing Argumentative Writing with Automated Feedback and Social Comparison Nudging. Comput. Educ., 191(C), dec 2022.