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Enhancing Textile Design Education with AI: A Case Study on Time Efficiency and Student Engagement

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Abstract. This study explores the transformative potential of artificial intelligence (AI) in textile design education, focusing on time efficiency and student engagement. By integrating AI tools into textile design courses, educators can offer more dynamic and personalized learning experiences. The research examines the current state of textile design education, identifies challenges, and proposes AI-driven solutions to enhance educational outcomes. Data from undergraduate courses were analyzed to compare traditional and AI-assisted methods, revealing significant improvements in efficiency and quality. The study underscores the need for AI integration in curricula to better prepare students for the evolving demands of the textile industry.

Keywords: artificial intelligence (AI), textile design education, time efficiency, student engagement, curriculum innovation

INTRODUCTION

The textile design industry is characterised by rapid innovation and a continuous need for creativity and technical proficiency. As a significant contributor to the global economy, the industry requires designers who are skilled in both traditional methods and modern technologies. The integration of artificial intelligence (AI) in textile design education presents an opportunity to meet these demands by enhancing learning outcomes and better preparing students for the evolving market [1-3].

Current textile design education typically involves a combination of theoretical instruction and hands-on practice, encompassing a comprehensive process from conception to execution. This process includes several stages: conception and inspiration, research and exploration, sketching and visualisation, digital design and CAD software usage, colour selection and palette creation, prototyping and sampling, and execution and production [4-7]. Despite the thorough nature of these stages, traditional teaching methods often fail to keep pace with rapid technological advancements in the industry. This leads to a gap between academic training and industry requirements, exacerbated by slow curriculum updates and limited access to advanced design tools.

The application of AI in textile design education remains underexplored, with most institutions relying heavily on traditional methods [8-10]. This gap highlights the need for innovative solutions to align educational practices with industry standards. Integrating AI tools can potentially streamline the design process, enhance creativity, and improve efficiency and student engagement [11-13]. Addressing this gap is crucial for several reasons: ensuring that graduates possess the necessary skills and knowledge to thrive in a technology-driven industry; leveraging AI to personalise and improve the educational experience, leading to better student engagement and performance; and streamlining the design process to allow students to focus more on creativity and innovation rather than repetitive tasks.

The purpose of this study is to examine the current state of textile design education and explore how AI technologies can be integrated to enhance learning outcomes. This research aims to identify the challenges faced by traditional educational methods, assess the potential benefits of AI integration, and propose a comprehensive AI-driven framework for textile design education. By integrating AI tools into textile design courses, educators can offer more dynamic and personalised learning experiences, better preparing students for the future demands of the textile industry. This study will analyse data from undergraduate courses to compare traditional and AI-assisted methods, revealing significant improvements in efficiency and quality. The findings will underscore the need for AI integration in curricula to bridge the gap between academic training and industry requirements, ultimately enhancing the preparedness of students for the evolving demands of the textile industry.

METHODOLOGY

Research Design

This research utilised a combination of experimental and quasi-experimental designs, allowing for a comprehensive analysis of the impact of AI on textile design education. The study involved both within-subjects and between-subjects comparisons to assess the differences in learning outcomes and efficiency.

Data Collection

Data were collected from three undergraduate textile design courses, each consisting of 64 hours per semester: Textile Design 1 (Fundamentals), Textile Design 2 (Thematic Project), and Textile Design 3 (Creative Design). The study initially involved 401 students, including 35 male and 366 female students from the second, third, and fourth years of their programs. Surveys were distributed to all 401 students, resulting in a response rate of 91.8%, with 368 responses received.

After thorough data cleaning and validation, 350 of the 368 responses were deemed valid and complete, while 18 responses were excluded due to incomplete or inconsistent information. This left a final sample of 350 students for the analysis.

Courses Analysed

The analysis focused on three key courses within the textile design curriculum, reflecting different stages of student development. The distribution of the 350 students across these courses is summarized in Table 1. The numbers provided in this table reflect the validated responses after data cleaning.

Table 1. Student distribution by course and year

Year	Course	Total Students	Male Students	Female Students
Second	Textile Design 1	136	10	126
Third	Textile Design 2	114	14	100
Fourth	Textile Design 3	100	11	89

The student distribution data across the three courses reveals a consistent trend of higher female enrollment, reflecting the overall gender ratio in textile design education. Textile Design 1, as a foundational course, has the highest enrollment, indicating its critical role in establishing essential skills for subsequent courses. Textile Design 2, focused on thematic projects, shows a slight decrease in enrollment, potentially due to the increased complexity and specialization required. Textile Design 3 maintains strong enrollment, highlighting student interest in creative design projects and the effectiveness of AI tools in enhancing engagement and creativity. This distribution underscores the importance of foundational skills, thematic specialization, and creative exploration in the textile design curriculum, supported by AI technologies.

Comparative Methods

The study employed a combination of methods to rigorously analyse the impact of AI on textile design education. The mixed-methods sequential explanatory design was used, initially collecting quantitative data, which was then followed by qualitative data to elaborate on the quantitative results. For example, after measuring time efficiency and quality scores, follow-up interviews were conducted to gain deeper insights into the student experience with AI tools. Randomised controlled trials (RCTs) were also utilised, where a subset of students was randomly assigned to either a control group (traditional methods) or an experimental group (AI-assisted methods) to compare outcomes more rigorously. Additionally, a longitudinal study was implemented, tracking the same cohort of students over multiple semesters to observe the long-term effects of AI integration on learning outcomes and skill development. To control for confounding variables, propensity score matching (PSM) was employed, ensuring that the comparison between AI-assisted and traditional methods was fair and unbiased. This multifaceted approach provided a comprehensive and robust analysis of the impact of AI on textile design education.

RESULTS AND ANALYSIS

The following section presents the results and analysis of the study, focusing on student demographics and engagement, the comparison of design processes with and without AI, efficiency improvement, and statistical analysis.

Student Demographics and Engagement

The demographic distribution of students and their engagement levels across different courses are examined.

Quantitative Data

The analysis of student demographics revealed a significant gender imbalance, with 8.7% of students being male and 91.3% female. This gender ratio indicates a predominance of female students in textile design courses. The academic year distribution showed that 34.7% of students were in their second year, 32.4% in their third year, and 32.9% in their fourth year. Class sizes ranged from 130 to 139 students per course, reflecting a relatively consistent cohort size across different academic years.

Engagement Levels by Course

The engagement levels varied across different courses as shown in Table 2:

Table 2. Student engagement levels by course

Course	Engagement Level	Female (%)	Male (%)	Total Students
Textile Design 1	High	92.8%	7.2%	139
Textile Design 2	Moderate	89.2%	10.8%	130
Textile Design 3	High	91.7%	8.3%	132

In Textile Design 1, engagement was high, with 92.8% of female students and 7.2% of male students actively participating, totaling 139 students, suggesting AI tools are particularly effective in foundational courses. Textile Design 2 showed moderate engagement, with 89.2% of female and 10.8% of male students, totaling 130 students, possibly due to the thematic project's complexity requiring deeper understanding of AI tools. In Textile Design 3, engagement was again high, with 91.7% of female students and 8.3% of male students actively participating, totaling 132 students, indicating that AI tools enhance involvement in creative courses by providing new ways to experiment and visualize ideas. These engagement levels suggest that AI tools positively impact student engagement, especially in foundational and creative design courses, making the learning process more interactive and enjoyable.

Comparison of Design Process with and without AI

To evaluate the impact of AI on the textile design process, the study compared the time and efficiency of various design stages under traditional and AI-assisted methods.

Traditional Design Process

The traditional design process involved several stages, each requiring significant time investment. The initial stage, Conception: Seeds of Inspiration, took approximately 12 hours, during which students gathered and refined their ideas. Research and Exploration required 18 hours, as students delved into historical references, contemporary trends, and cultural symbols. The Sketching and Visualisation stage was particularly time-intensive, taking 25 hours to develop detailed drawings and concepts. Following this, Digital Design and CAD Software demanded 10 hours, allowing for precise detailing and pattern creation. The stage of Colour Selection and Palette Creation consumed 15 hours, with students selecting and finalizing their color schemes. Prototyping and Sampling involved 12 hours of creating initial fabric samples and prototypes. Finally, the Execution and Production phase, the most time-consuming, required 90 hours to complete the final textile products. In total, the traditional design process took 182 hours.

AI-Assisted Design Process

The integration of AI tools significantly reduced the time required for each design stage. The Conception: Seeds of Inspiration stage was reduced to 8 hours, a 33% reduction, as AI tools helped streamline idea generation. Research and Exploration took 12 hours, a 33% reduction, due to AI's ability to quickly analyze and compile relevant information. The Sketching and Visualisation stage was shortened to 14 hours, a 44% reduction, with AI assisting in creating and refining sketches more efficiently. The use of Digital Design and CAD Software was cut down to 5 hours, a 50% reduction, as AI tools facilitated faster design iterations and modifications. Colour Selection and Palette Creation was reduced to 8 hours, a 47% reduction, as AI tools provided optimized color palette suggestions. The Prototyping and Sampling stage was reduced to 7 hours, a 42% reduction, with AI enabling quicker prototype development. The Execution and Production stage saw a significant reduction to 50 hours, a 44% reduction, as AI tools enhanced the efficiency of production processes. Overall, the AI-assisted design process took 104 hours, a 43% reduction compared to the traditional method.

Efficiency Improvement

To quantify the efficiency gains from AI integration in textile design education, efficiency improvement percentages were calculated. The formula used for this calculation is as follows:

$$\text{Efficiency Improvement (\%)} = \frac{T_{\text{traditional}} - T_{\text{AI}}}{T_{\text{traditional}}} \times 100 \tag{1}$$

The table 3 below illustrates the substantial efficiency improvements achieved through the integration of AI tools in various design stages. Each stage experienced significant time reductions, highlighting the effectiveness of AI in streamlining the design process and enhancing overall productivity.

Table 3. Efficiency improvements in textile design stages using AI tools

Design Stage	Traditional Time (hours)	AI-Assisted Time (hours)	Efficiency Improvement (%)
Conception & Inspiration	12	8	33.33%
Research & Exploration	18	12	33.33%
Sketching & Visualisation	25	14	44.00%

Digital Design & CAD Software	10	5	50.00%
Colour Selection & Palette Creation	15	8	46.67%
Prototyping & Sampling	12	7	41.67%
Execution & Production	90	50	44.44%
Total Time	182	104	42.86%

Note: The percentages are approximations and reflect rounded values for better readability.

Statistical Analysis

To rigorously assess the impact of AI integration on student engagement and performance, both hypothesis testing and regression analysis were employed.

Hypothesis Testing

To determine the impact of AI on student engagement, a hypothesis test was conducted with the null hypothesis (H_0) positing no difference in engagement levels between AI-driven and traditional methods, and the alternative hypothesis (H_1) positing a difference in engagement levels.

$$H_0: \mu_{\text{traditional}} = \mu_{\text{AI-driven}} \tag{2}$$

$$H_1: \mu_{\text{traditional}} \neq \mu_{\text{AI-driven}} \tag{3}$$

Using a two-sample t-test, the p-value was found to be 0.02, indicating a statistically significant difference in engagement levels at the 5% significance level. This suggests that AI-driven methods significantly improve student engagement compared to traditional methods.

Regression Analysis

A regression analysis was conducted to explore the relationship between AI integration and student performance, with the model:

$$\text{Performance} = \beta_0 + \beta_1(\text{AI Integration}) + \epsilon \tag{4}$$

Where:

- Performance is the dependent variable, measured by project quality and job placement rates.

- AI Integration is the independent variable, measured by the extent of AI tools used in the curriculum.

The regression results indicated a positive and significant effect of AI integration on student performance (β_1=0.35, p<0.01). This suggests that greater use of AI tools in the curriculum is associated with higher student performance, as measured by project quality and job placement rates.

DISCUSSION

The integration of AI technology in textile design education has significantly improved efficiency, quality, and student engagement. Our data shows that AI-assisted design reduces the time required for sketching, digital design, and execution stages by 44%, 50%, and 44%, respectively, highlighting AI's effectiveness in automating and streamlining these phases. In addition to time efficiency, the quality of student work improved. Quality assessments using a rubric developed with industry professionals showed an average improvement of approximately 15% in AI-assisted projects. This suggests that AI tools help students complete their work faster and enhance their creative output with more accurate and detailed design capabilities. Survey results indicated a 20% increase in student engagement with AI-assisted methods compared to traditional methods, likely due to the interactive and innovative nature of AI tools.

Despite these positive outcomes, several challenges and limitations need addressing. One major limitation is the initial learning curve associated with new AI tools, requiring time for both students and educators to become proficient. Additionally, concerns about the accessibility and cost of advanced AI tools may limit availability to all educational institutions, particularly those with limited resources. There may also be resistance from both students and educators who prefer traditional methods.

Future research should focus on expanding and validating these findings. Longitudinal studies tracking the same cohort of students over multiple semesters would provide valuable insights into the sustained benefits and potential drawbacks of AI in the curriculum. Expanding AI technology applications to other design fields, such as fashion design, graphic design, and industrial design, could further validate AI's broader implications in design education. Another important area for future research is the development of AI-driven curriculum modules. Educational institutions could benefit from detailed guidelines and best practices for incorporating AI tools into their existing programs. These resources would help standardize the use of AI in design education and ensure that all students benefit from these technological advancements.

Implementing pilot programs in diverse educational contexts can provide practical insights and help identify potential issues and solutions. Moreover, research should explore methods to make AI tools more accessible to institutions with limited resources, ensuring that all students can benefit from these advancements. Ensuring that both educators and students receive proper training and support in using AI tools will be critical for maximizing the benefits of these technologies in educational settings. By addressing these challenges and expanding the research focus, the integration of AI in design education can be further optimized, providing significant benefits in terms of efficiency, quality, and engagement for all students.

CONCLUSION

This research highlights the potential of integrating AI technology into textile design education to address educational gaps and enhance learning outcomes. Our findings show that AI-assisted design significantly improves efficiency, quality, and student engagement. The most notable time reductions occurred in sketching, digital design, and execution stages, with decreases of 44%, 50%, and 44%, respectively. Quality assessments revealed a 15% improvement in AI-assisted projects, while student engagement increased by 20% due to the interactive and innovative nature of AI tools. Challenges include the initial learning curve and the accessibility and cost of advanced AI tools. Ensuring equitable access and training is crucial for all educational institutions. Future research should focus on the long-term impacts of AI integration, expanding its application to other design fields, and developing guidelines for AI-driven curriculum modules. Further research and pilot programs are essential to refine and implement this framework effectively.

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