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Evaluating the Impact of a Textile-Based STEM Class Lecture on Middle School Learners: A Pre- and Post-Test Likert Analysis

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Abstract

STEM education often overlooks the practical, tactile domains of textiles and fashion, despite their strong connections to materials science, engineering, sustainability, and innovation. The world of textiles is evolving rapidly, gaining increased visibility and relevance across industries. Yet, despite its growing significance, many children remain unaware of the diverse career opportunities within the textile field. Textile education plays a crucial role in bridging this gap by introducing students to professions they may never have considered—far beyond the traditionally familiar roles of teacher, doctor, firefighter, or musician. By actively incorporating textiles into early educational experiences, we broaden students' understanding of innovation, sustainability, and science in everyday life. Continued exposure can inspire future careers as textile engineers, technologists, chemists, product developers, and other specialized roles that combine creativity with STEM. Elevating textile education ensures that the next generation recognizes the full spectrum of possibilities within this dynamic and essential industry. This study evaluated the effectiveness of an interdisciplinary textile-based STEM guest lecture designed to increase middle school students' conceptual understanding of

scientific principles in clothing and footwear, and their interest in STEM topics. The purpose was to expose students (n=75) to textile themes and topics to introduce, engage, and promote their understanding of textiles for potential future study of the topic. Students were given the same pre- and post-test of 7 questions and 5 Likert scale outputs ranging from strongly disagree to strongly agree. Data revealed students understanding of textiles increased drastically with a Wilcoxon change value of +2.19, and paired T-test significance across all questions suggesting the class lecture had a strong, significant effect on students understanding related to textiles science and textile applications.

Keywords: STEM education, textiles, engineering, apparel, footwear, middle school.

Introduction

The disconnect between STEM instruction and students lived experiences often contributes to disengagement, particularly in middle school (Osborne et al., 2003). Textiles offer an accessible, interdisciplinary entry point to science, engineering, and sustainability (Cunningham & Lachapelle, 2014). Despite their relevance, materials like clothing, footwear, and functional materials are rarely integrated into formal science education. This study investigates whether a short-format, hands-on textile-based intervention can measurably improve STEM-related understanding and interest. Science, Technology, Engineering, and Mathematics (STEM) education plays a pivotal role in preparing the next generation for a rapidly evolving, innovation-driven world. STEM literacy fosters not only foundational content knowledge but also critical thinking, creativity, and problem-solving skills applicable across academic disciplines and career pathways (National Research Council [NRC], 2011). As industries increasingly demand adaptable workers with interdisciplinary fluency, early and sustained engagement in STEM becomes vital to national competitiveness and individual empowerment (Honey, Pearson, & Schweingruber, 2014). The global call for improved STEM education has emphasized not just expanding content delivery, but also designing equitable, authentic learning experiences that mirror real-world inquiry and application (Bybee, 2010).

Research consistently shows that early exposure to STEM, particularly in middle school, significantly shapes students' attitudes, self-efficacy, and long-term interest in STEM fields (Maltese & Tai, 2011). This developmental stage is critical in that students begin to form durable perceptions about their abilities and career possibilities, and those with early positive experiences are more likely to pursue advanced STEM coursework and professions (Archer et al., 2013). However, access to high-quality, hands-on STEM experiences is often uneven, especially in under-resourced schools or communities of color. Addressing these disparities through targeted, engaging STEM programming has been shown to increase motivation, identity formation, and achievement among historically underrepresented groups (Tan et al., 2013).

To evaluate the effectiveness of such interventions, pre- and post-learning assessments are essential for measuring cognitive and affective gains. These tools help researchers and educators identify growth in conceptual understanding, confidence, and interest following participation in STEM activities (Uzunboylu & Tuncay, 2010). When combined with inclusive, design-based learning frameworks, pre/post methods can validate the impact of STEM enrichment efforts and support iterative improvements in instructional design. This study contributes to this growing body of literature by assessing middle school student outcomes following a research-driven STEM engagement activity focused on textiles, materials science, and sustainable innovation.

Methods

A cohort of middle school students grades 6-8 (n = 75) participated in a hands-on 45-min lecture over the course of the school day, related to textiles science and applicable industries. After students were told the title of the lecture, they were given a 7-item Likert scale pre-test to measure their current knowledge, understanding, and interest in textiles and its applications. Students were asked to rate the questions on a 5-point Likert scale from 1-strongly agree, 2-disagree, 3-neutral, 4-agree, and 5-strongly agree. Lecture topics included:

1. Textile definitions
2. Video – From Wood Cellulose to Textile Fibers
3. High Fashion & Couture (Apparel Textiles)
4. Ready-to-wear Fashion (Apparel Textiles)

5. Industrial Textiles
6. Performance Textiles
7. Home Textiles
8. Occupational Textiles
9. Automotive Textiles
10. Medical Textiles
11. Non-woven Textiles
12. Textiles Engineering
13. Video – Business Insider, How New Balance Shoes are Made
14. Textile Innovation – Smart Textiles
15. Textile Recycling

The post-test comprised the same 7-item and Likert scale response as seen in Table 1. Paired pre/post responses were analyzed using the Wilcoxon signed-rank test and effect size was calculated using rank-biserial correlation. The lecture concluded by fabric, fiber, and trim hand analysis of materials samples and swatches related to the lecture topics.

Table 1 – Likert Scale Survey Questions

Likert Scale Questions 1=Strongly Agree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree
1. I understand what textiles are and why they matter in daily life.
2. I know how science is used to improve the clothing and shoe we wear.
3. I understand how engineering affects the design of product like sneakers, sportswear, or smart fabrics.
4. I can explain how materials or design can impact how the body moves or feels.
5. I feel confident talking about new fashion innovations or materials (like 3D-printed

clothes or recycled fabrics).

6. I understand how sustainability and technology are connected in fashion today.

7. I am interested in learning more about science, engineering, or innovations in fashion and textiles.

Results

All seven survey items showed statistically significant improvement ($p < 0.01$). The greatest gains were in understanding what textiles are and why they matter ($\Delta = +2.19$, $r = 0.89$) and understanding biomechanics in design ($\Delta = +1.01$, $r = 0.79$). Even interest in STEM topics increased significantly ($\Delta = +0.42$, $p = 0.0063$). Effect sizes ranged from moderate to large ($r = 0.42$–0.89), indicating meaningful learning outcomes seen in Table 2 and Figure 1 Pre- and post-test comparisons.

Table 2: Wilcoxon Analysis Results

Question	Pre-Mean	Post Mean	Δ Change	p-value	Effect Size (r)
Q1. Understanding of textiles	2.20	4.39	+2.19	<.001	0.89
Q2. Science in apparel	3.33	4.33	+1.00	<.001	0.76
Q3. Engineering and design	3.65	4.47	+0.82	<.001	0.71
Q4. Biometrics	3.17	4.18	+1.01	<.001	0.79
Q5. Innovation confidence	3.13	3.83	+0.70	<.001	0.62
Q6. Sustainability	3.28	4.17	+0.89	<.001	0.67
Q7. STEM interest	3.54	3.96	+0.42	.0063	0.42

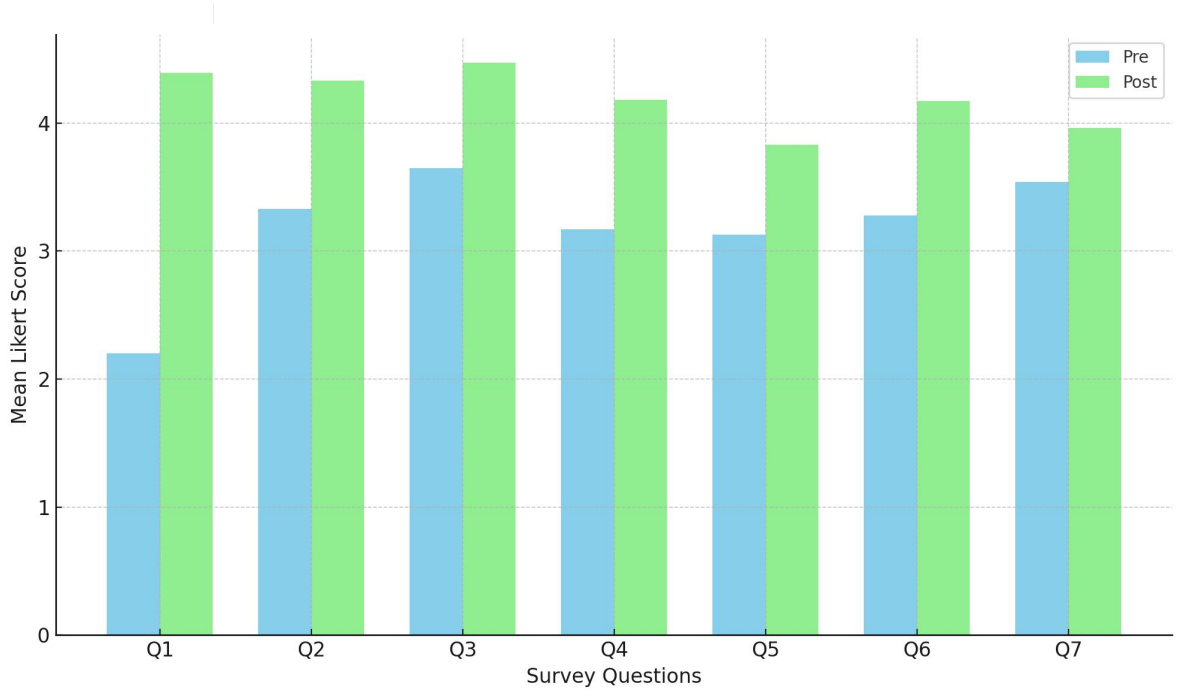

Figure 1: Pre- and Post-test Likert Score Comparison

Discussion

The results from this hands-on, interdisciplinary guest lecture suggest that textile-based STEM learning significantly improves middle school students' conceptual understanding and interest in science and engineering. The most substantial learning gains were in foundational knowledge — including what textiles are, how they function biomechanically, and how engineering and material choices shape product performance. These outcomes point to a critical gap in traditional science education where abstract concepts are often decoupled from lived experience. When students are shown how materials science and biomechanics are already embedded in familiar items like sneakers, sportswear, or recycled fabrics, the content becomes tangible, and their engagement rises accordingly.

The disconnect between STEM content and culturally relevant or everyday contexts is a broader systemic issue in science education. Too often, students — particularly girls and underrepresented minorities — disengage from science not because of inability, but because they do not see themselves or their interests reflected in the material. Integrating textiles and fashion, fields often marginalized in core science curricula, helps fill that representational gap while maintaining rigorous STEM content. By treating apparel and materials as serious

scientific domains, we make STEM visible in the spaces students occupy every day. These results suggest that when science is taught through frameworks that reflect both utility and identity, student learning and curiosity increase in meaningful, measurable ways. Integrating textile science into classrooms provides not just access, but agency, by validating students' identities (Archer et al., 2015).

Conclusions

This study provides empirical support for including textile and fashion applications in STEM education to engage students in tangible, relevant science. Findings suggest that textile-based lectures and hands-on learning can significantly enhance both STEM understanding and interest among middle school learners. In current practice, educators can consider integrating materials science through fashion and footwear contexts, aligning with diverse student interests. Future studies should examine long-term effects and retention of knowledge, expand to multiple schools and diverse demographics, and incorporate qualitative data to understand how identity, interest, and engagement evolve over time throughout high school and higher education.

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