Advancing Students' Knowledge of Sustainability-Driven Innovation in Denim Production

Jin Su, Elena Karpova, Nancy Hodges, Kittichai (Tu) Watchravesringkan, Md. Hasan Sheikh, and Charlotte Mills
University of North Carolina at Greensboro, USA

Keywords: Sustainability, denim, cotton, innovation

Introduction and Purpose. The denim industry has benefited from the enduring popularity of jeans across the globe. At the same time, it has a significant negative impact on the environment, through its excessive use of water and chemicals due to specialized production and finishing processes. Despite the efforts that many denim brands have made to address environmental issues through various sustainability-driven initiatives, the negative perception about the industry's impact remains. Indeed, Karell and Niinimäki (2020) pointed to a general lack of knowledge in the marketplace regarding efforts to advance sustainability in denim production. Such knowledge is particularly important for future industry professionals (Jaiswal et al., 2024). Therefore, this study aims to foster apparel students' knowledge of denim sustainability. The two research objectives were (1) to increase students' knowledge about denim sustainability innovations and (2) to enhance students' competency in applying this knowledge to promote sustainability among denim brands. To address the objectives, we employed problem-oriented and project-based learning (POPBL) as a pedagogical approach to develop an experiential learning module.

Literature Review. Jeans are emblematic of American culture, symbolizing ruggedness and durability (Miller & Woodward, 2007). In 2023, global sales of jeans reached $98 million, with projections for an increase to $128 million by 2028 (Euromonitor International, 2024). In recent years, sustainability has emerged as a central focus in both denim production and consumption to solve the sector's environmental impacts, which are characterized by heavy water and energy usage, chemical applications, and waste generation (Amutha, 2017). Consequently, many denim brands have been experimenting with eco-friendly production methods, integrating organic or regenerative cotton, implementing water-saving techniques, and investing in denim recycling initiatives.

Research indicates that incorporating sustainability topics into curricula better equips students to address the environmental impacts caused by fashion industry (Smith, 2020). POPBL is an effective, student-centered instructional strategy in which complex, real-world problems are used as the vehicle to promote learning of concepts and principles, as opposed to a presentation of facts and concepts within a lecture (Lehmann et al., 2008). Based on the literature review, the following hypotheses were proposed.

After the completion of the experiential learning module, students will have:

H1: a higher level of knowledge about denim sustainability ($H1_{(1)} \sim H1_{(10)}$; 10 aspects of denim sustainability knowledge)

H2: a higher level of competency for addressing denim sustainability ($H2_{(1)} \sim H2_{(7)}$; 7 denim sustainability competencies)

H3: a more positive attitude toward purchasing sustainable denim products

H4: a stronger interest in the initiatives that promote denim circularity
H5: a greater intention to pay more for sustainable denim products

Learning Module Description. We developed an experiential learning module based on CottonWorks™ website resources for students to use science-based facts and integrate innovations related to denim sustainability in their projects. The learning module included five lectures, three mini assignments, and a semester-long POPBL team project titled "Buying and Merchandising Sustainable Denim." Students were asked to research a sustainable denim company's business strategies and practices, develop a retail business plan for a sustainable denim brand of their choice, and apply their knowledge about retail math to create a six-month merchandise plan. At the end of the semester, students submitted their reports on sustainability strategies and student teams submitted project videos and powerpoint presentations for their sustainable denim retail business plans and six-month merchandise Excel spreadsheets for their sustainable denim merchandise budget.

Method. A structured questionnaire was developed to measure students' knowledge about cotton and denim sustainability, their level of competency related to denim sustainability, and their perceptions of sustainable denim (attitude and willingness to pay) (Annelin & Boström, 2023; Connell & Kozar, 2012; Hyytinen, 2023). A five-point Likert-type scale was used, and open-ended questions were included. Upon receiving approval from the University's IRB, all students in an apparel retail buying class were invited to participate in the study by completing two online surveys: one before the learning module (pre-test survey) and the other after the learning module (post-test survey). Thirty respondents completed both surveys. Half of participants were between 19-21 years old, followed by 22-24 (37%). Two-thirds were female. Nearly half were African American (47%), followed by White (37%).

Results. Paired sample *t*-tests were conducted to test the hypotheses. As shown in Table 1, after the completion of the learning module, students displayed a higher level of knowledge across all 10 aspects of denim sustainability and showed increased competencies in denim sustainability. Students perceived sustainable denim products as worthwhile and expressed greater interest in initiatives or programs promoting denim circularity. Moreover, students displayed stronger intentions to pay more for sustainable denim garments. Therefore, all hypotheses were supported.

Conclusions and Implications. The results demonstrate the effectiveness of the learning module in enhancing students' knowledge about denim sustainability and increasing their competency in understanding sustainability innovations in denim production, seeking and assessing specific information, solving problems, and improving verbal communication about denim sustainability.

Table 1

Questionnaire Item	t-value	Questionnaire Item	t-value
Student Knowledge: Pre vs Post			
1. Denim fabric production	-3.898***	2. Denim product life cycle	-4.026***
3. The environmental impact of disposed denim clothing that was incinerated (burned)	-5.215***	4. The environmental impact of denim clothing waste that went to a landfill	-5.174***
5. The benefits of sustainable denim clothing	-6.227***	6. Technology innovations for producing sustainable denim clothing	-5.058***
7. How to transform old denim clothing into something new	-4.475***	8. Innovative denim recycle/reuse/repair program(s)	-6.021***
9. Sustainable denim market	-6.679***	10. Brands/retailers that sell sustainable/circular denim clothing	-7.763***
Student's Level of Competency: Pre vs Post			
1. Seeking specific information about denim sustainability from different sources	-3.496**	2. Assessing trade-offs in the context of denim consumption	-3.002**
3. Understanding sustainability issues related to the denim industry	-4.014***	4. Understanding sustainability innovations related to denim consumption and disposal	-4.535***
5. Solving specific problems related to denim sustainability	-3.674***	6. Verbal communication about denim sustainability	-2.984**
7. Using CottonWorks™ resources to learn denim sustainability	-7.017***		
Student's Perceptions: Pre vs Post			
1. Buying sustainable denim products is Extremely a waste of time/money -- Extremely worthwhile	-2.257*	2. I am interested in initiatives or programs that promote denim circularity	-4.176***
3. I am willing to pay more for denim garments that are produced through a circular fashion initiative.	-2.282*		

Note. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

References

Amutha, K. (2017). Environmental impacts of denim. In S. S. Muthu (Ed.), *Sustainability in denim* (pp. 27-48). Woodhead Publishing. https://doi.org/10.1016/B978-0-08-102043-2.00002-2

Annelin, A., & Boström, G. O. (2023). An assessment of key sustainability competencies: a review of scales and propositions for validation. *International Journal of Sustainability in Higher Education, 24*(9), 53-69. https://doi.org/10.1108/IJSHE-05-2022-0166

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101.

Connell, K. Y. H., & Kozar, J. M. (2012). Sustainability knowledge and behaviors of apparel and textile undergraduates. *International Journal of Sustainability in Higher Education, 13*(4), 394-407. https://doi.org/10.1108/14676371211262335

Cotton Incorporated. (2023). Cotton Incorporated's Blue Jeans Go Green™ Program Highlights Positive Impact Of Textile Recycling Efforts On America Recycles Day. Retrieved January 18, 2024 from https://lifestylemonitor.cottoninc.com/cotton-incorporateds-blue-jeans-go-green-program-highlights-positive-impact-of-textile-recycling-efforts-on-america-recycles-day/

Euromonitor International. (2024). Jeans in World: Market Size. Euromonitor International.

Hyytinen, H., Laakso, S., Pietikäinen, J., Ratvio, R., Ruippo, L., Tuononen, T., & Vainio, A. (2023). Perceived interest in learning sustainability competencies among higher education students. *International Journal of Sustainability in Higher Education, 24*(9), 118-137. https://doi.org/10.1108/IJSHE-06-2022-0198

Jaiswal, G., Hopfer, E. N., & Dixon, D. L. (2024). Sowing the seeds of change: educating emerging textile and apparel professionals on sustainability from cotton industry perspective. *International Journal of Sustainability in Higher Education, 25*(3), 649-668. https://doi.org/10.1108/IJSHE-08-2022-0282

Karell, E., & Niinimäki, K. (2020). A mixed-method study of design practices and designers' roles in sustainable-minded clothing companies. *Sustainability, 12*(11), 4680. https://doi.org/10.3390/su12114680

Lehmann, M., Christensen, P., Du, X., & Thrane, M. (2008). Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education. *European Journal of Engineering Education, 33*(3), 283-295. https://doi.org/10.1080/03043790802088566

Miller, D., & Woodward, S. (2007). Manifesto for a study of denim. *Social Anthropology, 15*(3), 335–351. https://doi.org/10.1111/j.0964-0282.2007.00024.x

Smith, C. (2020). Experiential learning in the fashion sustainability classroom: The development of a fashion revolution week event using creative problem-solving. *International Textile and Apparel Association Annual Conference Proceedings, 77*(1). doi: https://doi.org/10.31274/itaa.11737

Zhao, M., Zhou, Y., Meng, J., Zheng, H., Cai, Y., Shan, Y., Guan, D., & Yang, Z. (2021). Virtual carbon and water flows embodied in global fashion trade—A case study of denim products. *Journal of Cleaner Production, 303*, 127080. https://doi.org/10.1016/j.jclepro.2021.127080

This project was partially funded by Cotton Incorporated.
The CottonWorks™ website is a resource developed and maintained by Cotton Incorporated.