Enhancing Visualization Skills and Patternmaking in Fashion Education: A Systematic Literature Review of Studies

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ABSTRACT

The demand for proficient patternmaking skills in fashion design education underscores the importance of enhancing students' visualization abilities. This systematic literature review investigates current practices in fashion higher education aimed at developing visualization skills in patternmaking. Drawing on Self-Determination Theory (SDT) principles, which emphasize the satisfaction of basic psychological needs, this review examines the impact of satisfaction in the context of patternmaking education. Following the PRISMA criteria, the review synthesizes findings from studies identified through Web of Science, IEEE Xplore, Science Direct and Scopus databases. Thematic analysis reveals four major themes: research area, instrumentation and language, study location, and antecedents and outcomes of satisfaction and frustration. The findings highlight the significance of aiding students with adjustment strategies to understand the underlying causes and consequences of satisfaction and frustration in patternmaking education. Practical implications include the development of adaptation techniques to achieve academic success and recommendations for future research directions in this field.

Keywords: Patternmaking, Visualization skills, Fashion education, Higher education, SLR

INTRODUCTION

Patternmaking is a fundamental skill in fashion design, acting as the structural foundation upon which garments are developed. It involves translating design concepts into precise templates that guide fabric cutting and garment construction. Mastery of patternmaking requires a deep understanding of proportions, fabric behavior, and garment fit, ensuring that designs are not only aesthetically pleasing but also functional and wearable. Beyond its technical aspects, patternmaking plays a crucial role in the creative process, allowing designers to experiment with silhouettes, draping techniques, and garment manipulation. A well-constructed pattern serves as a bridge between conceptual ideas and physical clothing, making it an essential skill for fashion professionals. Additionally, proficiency in patternmaking enables designers to produce garments that align with industry standards, ensuring consistency in sizing, shaping, and overall design execution.

In an educational setting, patternmaking is often taught through a combination of theoretical knowledge and hands-on practice, where students learn drafting, draping, and digital pattern development techniques. The ability to visualize and manipulate patterns effectively is fundamental to innovation in fashion design, as it enables designers to experiment with diverse silhouettes, garment structures, and fit adjustments. This skill allows for greater flexibility in creating unique, customized designs that cater to specific client needs, market trends, and emerging fashion aesthetics. Furthermore, mastering pattern manipulation fosters creativity, as designers can push conventional boundaries by altering basic forms into more complex, innovative structures. Beyond creativity, proficiency in patternmaking is closely tied to problem-solving skills in fashion design. Designers

often face challenges related to fit, material constraints, and production efficiency. A solid grasp of pattern construction enables them to troubleshoot these issues effectively, adjusting garment components to achieve the desired aesthetic while maintaining structural integrity. This ability is particularly valuable in couture fashion, where bespoke garments require intricate adjustments, as well as in mass production, where efficiency and consistency are essential. Patternmaking is a foundational skill in fashion design, serving as the blueprint upon which garments are crafted. Within the dynamic landscape of fashion higher education, cultivating visualization skills in patternmaking emerges as a critical aspect of students' development (Moore, 2019).

This systematic literature review aims to delve into current practices within fashion higher education, focusing specifically on strategies to enhance students' visualization skills in patternmaking (Yang, Song & Tong, 2017). Visualization skills are essential for aspiring fashion designers, as they bridge the gap between conceptual creativity and the practical realization of garments. These skills empower designers to mentally construct and manipulate three-dimensional (3D) garment structures, enabling them to anticipate how a design will translate from a two-dimensional (2D) sketch or pattern into a wearable piece. The ability to foresee the drape, flow, and fit of a garment on the human form is crucial for ensuring that the final product aligns with the intended aesthetic and functional objectives. A strong foundation in visualization skills enhances a designer's ability to experiment with complex garment structures, pattern manipulations, and innovative silhouettes without the immediate need for physical prototypes. This capability not only streamlines the design process but also fosters efficiency in material use, reducing fabric waste and production costs.

Additionally, advanced visualization skills enable designers to communicate their ideas more effectively to patternmakers, manufacturers, and clients through technical drawings, digital renderings, and draping simulations. In the context of patternmaking education, nurturing visualization skills is particularly significant, as it allows students to interpret flat patterns with a deeper understanding of how they will translate into 3D forms. By honing these abilities, students develop spatial awareness, problem-solving capabilities, and an intuitive grasp of garment construction principles. This is especially important in an industry that increasingly integrates digital tools, such as 3D garment simulation software, to enhance design accuracy and efficiency. Given the evolving demands of the fashion industry, strengthening students' visualization skills in patternmaking is crucial for equipping them with the technical and creative competencies required for professional success. A well-developed ability to visualize garments in different dimensions enables designers to push creative boundaries, innovate with new design concepts, and refine their craftsmanship, ultimately contributing to the advancement of fashion design as both an art and a technical discipline (Yang, Song & Tong, 2017; Thorisdottir & Johannsdottir, 2020).

Saeed, Foaud and Fattouh (2017) state that proficiency in patternmaking and visualization is essential for career advancement in today's competitive fashion industry. Fashion higher education plays a crucial role in preparing students for the industry's demands by providing opportunities to develop and refine their visualization skills in patternmaking. By honing these skills, students can better navigate the complexities of garment construction and design, positioning themselves for success in a rapidly evolving industry landscape. To effectively enhance visualization skills in patternmaking, it is imperative to understand the current practices employed within fashion higher education. This involves examining pedagogical approaches, instructional methodologies, and technological tools to facilitate learning and skill development. By gaining insight into these practices, educators and researchers can identify strengths, challenges, and areas for improvement in current educational strategies (Saeed, Foaud & Fattouh, 2017; Appiah, 2023).

Insights into pedagogical approaches that foster visualization skills in patternmaking are crucial for optimizing teaching and learning experiences within fashion higher education (Adar & Lee-Robbins, 2023). Educators can enhance students' understanding and application of patternmaking principles by exploring effective instructional methods, feedback mechanisms, and experiential learning opportunities. Additionally, insights into the cognitive processes involved in visualization can inform the development of tailored teaching strategies to meet diverse learning needs. The findings of this systematic literature review have significant implications for curriculum development in fashion higher education (Conlon, 2024; Conlon and Gallery, 2024). By identifying best practices and areas for improvement in enhancing visualization skills in patternmaking, educators can refine curriculum design to better align with industry demands and student learning outcomes. Additionally, insights

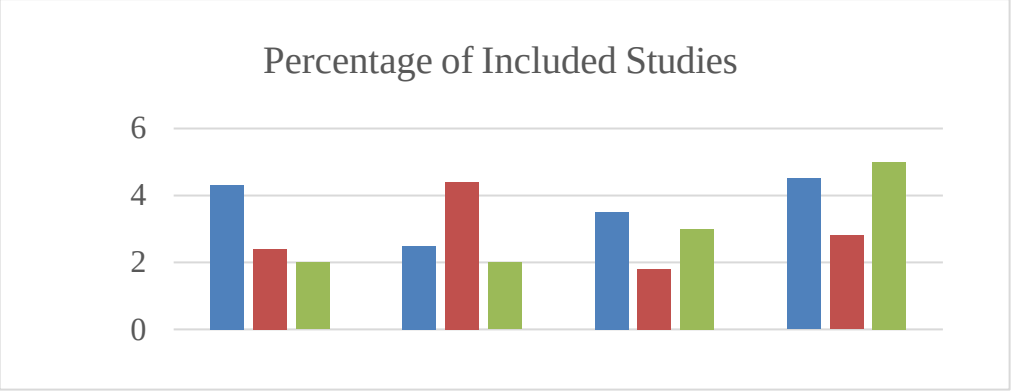
from the review can inform the integration of innovative teaching methodologies and technologies to enhance the effectiveness of patternmaking education (Conlon, 2024).

MATERIAL AND METHODS

A considerable body of literature addressing systematic assessments has been conducted globally, yet the focus has been relatively narrow within the domain of fashion education and patternmaking (Ildephonse, 2023; Pongo, Asare, & Abdul-Fatahi, 2015). This section addresses the need for a systematic analysis of current practices in fashion higher education related to enhancing visualization skills in patternmaking. The methodology employed in this systematic literature review is outlined below. In navigating the vast expanse of scholarly literature, the methodology guiding this systematic exploration unfolds akin to a meticulously curated fashion collection. Just as a discerning designer selects fabrics and hues to weave a coherent narrative, the selection of Web of Science, IEEE Xplore, Science Direct and Scopus databases mirrors the deliberate choice of premium materials. These databases, renowned for their robustness and breadth, are the foundation for this scholarly pursuit.

Much like the precision required in patternmaking to ensure flawless fit and form, the criteria for inclusion and exclusion in this review are meticulously crafted. Just as a master tailor scrutinizes each stitch for quality and precision, only articles meeting the exacting standards of relevance and rigor find their place in the tapestry of this systematic literature review. In the intricate dance of patternmaking, every cut and seam serve a purpose, shaping the fabric into a harmonious whole. Similarly, data extraction and synthesis involves delicately weaving together the threads of information gleaned from each selected study. Like a skilled artisan crafting a bespoke garment, each key finding and methodology is expertly curated to illuminate the overarching themes of fashion education and visualization skills in patternmaking. As a discerning connoisseur of fashion, attuned to the nuances of craftsmanship, the assessment of study quality is conducted with a keen eye for detail. Just as a fashion critic evaluates the couture creations on the runway, each selected study undergoes rigorous scrutiny to ascertain its scholarly merit and contribution to the discourse on fashion education and patternmaking by Coneybeer et al. (2023).

Figure I The Visualization Skills on Fashion Report Based On data from 2000 to 2023



Indication of colour:

Blue: patternmaking :20%
Red: Higher Education :30%
Green: Fashion Education: 24%
Purple: Patternmaking: 26%

Drawing inspiration from the elegance and precision of haute couture, the PRISMA approach serves as the guiding compass in this scholarly endeavor. Like the meticulous attention to detail in crafting a couture gown, the PRISMA framework ensures transparency and rigor in the systematic selection, evaluation, and synthesis of relevant literature forms (Hutton et al., 2015). In the final flourish of this scholarly ballet, the synthesized findings are presented with the finesse and flair of a runway showcase. Much like a fashion designer orchestrating a dazzling display of creativity, the data analysis unfolds to reveal the intricate patterns and themes woven

throughout the landscape of fashion education and higher learning in patternmaking.

Identification

Keyword identification following searches for similar and similar terms using thesauruses, dictionaries, encyclopaedias and previous research are the first steps in the identification process. For example, search strings for the Scopus and Web of Sciences databases are created after all relevant phrases are determined. The identification procedure involves finding similar words, terms and keywords, which form the primary key with different word variations. The objective is to provide a curated database with additional opportunities to search and evaluate relevant content (Coneybeer et al., 2023; Mohamed Shaffril at al., 2020).

Reffering to Mohamed Shaffril at al, (2020), to find synonyms in this study, the author used an online thesaurus, phrases from previous studies, data-driven keywords and keywords provided by experts. Another way to enrich keywords is to use boolean operators, truncation, phrase searches, database field code operations, and wild card operations to unlock the full potential of database search strings (Table 1). Relevant combinations of keywords that have been used, such as 'children,' 'children,' 'adults,' 'adolescents' or 'adolescents.' Boolean operators, truncation, field codes and wildcards were used to improve the current phrase and generate a comprehensive search string. In addition, the Scopus database produced 144 related articles as search results. Although the results from Web of Science were only about 5, Science Direct only got more than 13, while IEEE Explore Search got 115 research articles while successfully obtaining 139 articles from both databases during the first part of the systematic review procedure.

TABLE I The Search String Utilized For The Systematic Review Process

Database	**Search string**
Scopus	TITLE-ABS-KEY ("Visualisation skill" OR "Visual") AND ("Patternmaking" OR "Pattern") AND fashion* AND educate*)
Web of Science	Machine ("Visualisation* skill" (Topic) or patternmaking* (Topic) and fashion* (Title))
Science Direct	Visualisation skill AND patternmaking AND fashion
IEEE Explore Search	("Full Text & Metadata": fashion education) AND ("All Metadata": Visualisation skill) OR ("All Metadata": Patternmaking)

Screening

Based on the standards provided by the researchers, database sorting function was used to automatically identify all 139 papers included in this investigation. The authors have established exclusion and inclusion criteria. First, only journal articles containing empirical data were selected, meaning theses, proceedings, books or conferences were all rejected. Second, the search attempt excluded non-English language publications and focused only on publications published in English to minimize misunderstandings and translation problems. The third criterion was related to the timeliness of the research. To capture the development and progression of studies within the field, a specific publication timeframe was established, focusing on research published between 2000 and 2023. This timeframe was chosen to provide a balanced perspective on both historical developments and recent advancements, allowing researchers to identify trends, methodological shifts, and emerging themes in the literature. By setting a clear temporal boundary, the study ensured that the selected articles reflected the evolving nature of research within the specified domain. By implementing these carefully defined inclusion and exclusion criteria, the study was able to filter out irrelevant or outdated sources, ensuring that the final selection of articles was both methodologically sound and aligned with the study's research objectives. This structured approach contributed to the reliability and validity of the findings, offering a well-rounded analysis of the existing body of knowledge. Table 2 lists the criteria for exclusion and inclusion:

TABLE 2 Criteria For Inclusion And Exclusion

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	Between 2000 until 2023	< 2000
Literature type	Journal (only research articles)	Journal (book chapter, conference proceeding)
Subject Area	Fashion design education, Arts and Humanities, as well as fashion	Besides Fashion design education, Arts and Humanities, as well as Fashion

This process resulted in a reduction of one duplicated article and the exclusion of 79 items that did not satisfy the inclusion criteria. Following this screening phase, the remaining 19 articles advanced to the next stage of the selection process, referred to as the eligibility assessment. This phase involved a more detailed evaluation to verify that these studies fully aligned with the research focus and methodological requirements. During eligibility assessment, factors such as research design, data validity, sample size, and relevance to the study's scope were scrutinized. This step was crucial in refining the final dataset, ensuring that only the most pertinent and high-quality studies contributed to the research findings. By systematically narrowing down the selection, this process strengthened the reliability of the study and minimized the risk of including irrelevant or low-quality sources. The thorough approach ensured that the final pool of studies provided a comprehensive and credible foundation for analysis, ultimately enhancing the overall validity of the research outcomes.

Eligibility

Eligibility resembles the third step in the process. Here, authors manually check the obtained articles to assure that all the articles left (after the screening phase) fulfill the criteria. In addition, the abstracts and titles of the publications were read to achieve this (Coneybeer et al., 2023; Hutton et al., 2015). A total of 19 articles have been chosen for the third step, entitled eligibility. All articles' titles and main material were rigorously examined at this stage to guarantee that they met the inclusion criteria and were related to the present study's research goals. As a result, 4 articles were selected in this stage. The flow diagram for the investigation is depicted in Figure 2.

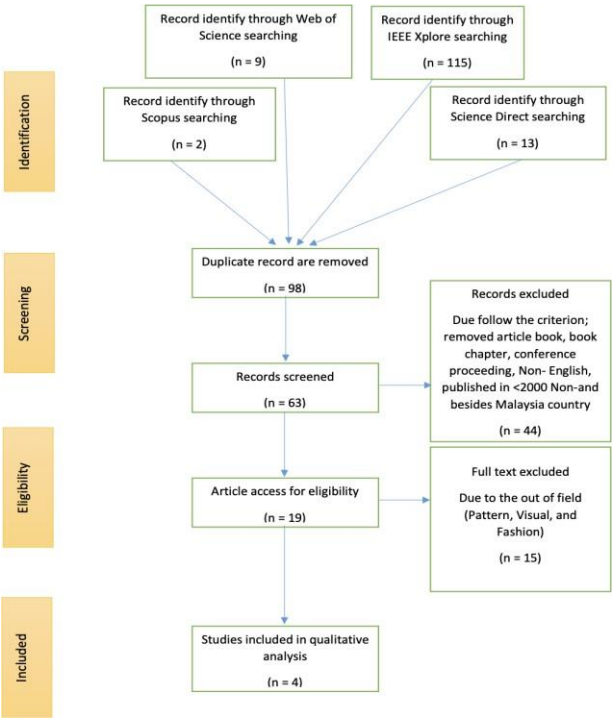


Fig 2. Flow diagram of the proposed searching study

RESULT AND FINDING

As highlighted by Moleko (2012), visualization skills play a fundamental role in patternmaking within fashion education, addressing the needs of students and professionals globally. These skills are essential for enhancing accuracy and efficiency, also allowing designers to transform conceptual ideas into precise, functional garment patterns. The ability to mentally construct and manipulate two-dimensional (2D) patterns into three-dimensional (3D) garment forms is a crucial aspect of fashion design education. As noted by Tsarouchis et al. (2021), visualization skills not only support the creative process but also improve technical execution, ensuring that garments are well-structured, proportionate, and aligned with design. The development of visualization skills is particularly important in the evolving landscape of fashion education, where both traditional and modern methodologies are employed to enhance students' competencies. The combination of these approaches is essential for equipping aspiring designers with the necessary technical knowledge and design proficiency to thrive in the fast-paced and competitive fashion industry. Despite the significance of visualization skills in patternmaking, research on this subject remains relatively limited. A systematic search process identified only four relevant articles that specifically explored the relationship between visualization skills and patternmaking education. Three basic themes (Figure 3) that were used to categorize all the articles include (1) The Development of Technical Skills, (2) The Integration of Technology, and (3) Project-Based Learning and outcomes of frustration (Table 3) is summary Journal Articles of Visualisation skill and Patternmaking in fashion education.

Table 3 The Research Article Finding Based on The Proposed Searching Criterion

NO	Author	Journal	Title	Scopus	WoS	Science Direct	IEEE Explore Search	Remarks
1	Xing X.; Li L.; Xu C.	(2022) Journal of Silk	Studies on the traditional embroidery consumer market segmentation and characteristics based on fashion value perception.	/				Fashion
2	Pushkareva N.L.; Mitsyuk N.A.	(2017) Ural'skij Istoriceskij Vestnik	Modernization of the early childhood material culture in the Russian nobility families of the second half of the 19th - Early 20th century	/	/			Pattern
3	Al-Shanfari, L; Baber, C and Epp, CD	(2017) 18th International Conference	Student Preferences for Visualising Uncertainty in	/	/			Visualisation Skills

		on Artificial Intelligence in Education (AIED)	Open Learner Models					
4	Kösa, T and Karakus, F	(2018) European journal of engineering research	The effects of computer-aided design software on engineering students' spatial visualisation skills		/		/	Visualisation Skills
5	Koca, S and Çakir, R	(2022) Behaviour & Information Technology	Assessment of visualisation skills in biochemistry students		/	/		Visualisation Skills
6	Kim, S and Kim, HY	(2023) International Journal of Fashion Design, Technology and Education	Creative exploration: zero-waste fashion design practices with traditional Korean clothing		/		/	Fashion
7	Arana, C; Franco, IB; (...); Sedhai, J	(2020) Actioning the Global Goals for Local Impact: Towards Sustainability Science, Policy, Education and Practice	SDG 15 Life on Land A Review of Sustainable Fashion Design Processes: Upcycling Waste Organic Yarns		/			Fashion
8	Bednall, A	(2020) Patternmaking History and Theory	Re-Make, Re-Model, Re-define: Fashioning a Nation's Identity		/		/	Fashion
9	Finn, A and Fraser, K	(2012) Edulearn12: 4th International Conference on Education and New Learning	Contemporary Classrooms: Exploring Blackboard Academic Suite™ And Virtual Teaching Spaces for Fashion Education		/			Fashion

		Technologies						
10	Farrer, J and Finn, A	(2010) Innovative Developments in Design and Manufacturing	The power of a single prototype: Sustainable fashion textile design and the prevention of carcinogenic melanoma [28]		/			Pattern
11	Gareth Figgess;Julie Fogarty	(2018) Frontiers in Education Conference (FIE)	Visualization Skills and Student Success in Engineering Disciplines				/	Visualisation Skills
12	Benjamin Bach; Mandy Keck	(2023) Transactions on Visualization and Computer Graphics	Challenges and Opportunities in Data Visualization Education: A Call to Action				/	Visualisation Skills
13	Fearn Bishop; Johannes Zagermann	(2020) transactions on Visualization and Computer Graphics	Construct-A-Vis: Exploring the Free-Form Visualization Processes of Children				/	Visualisation Skills

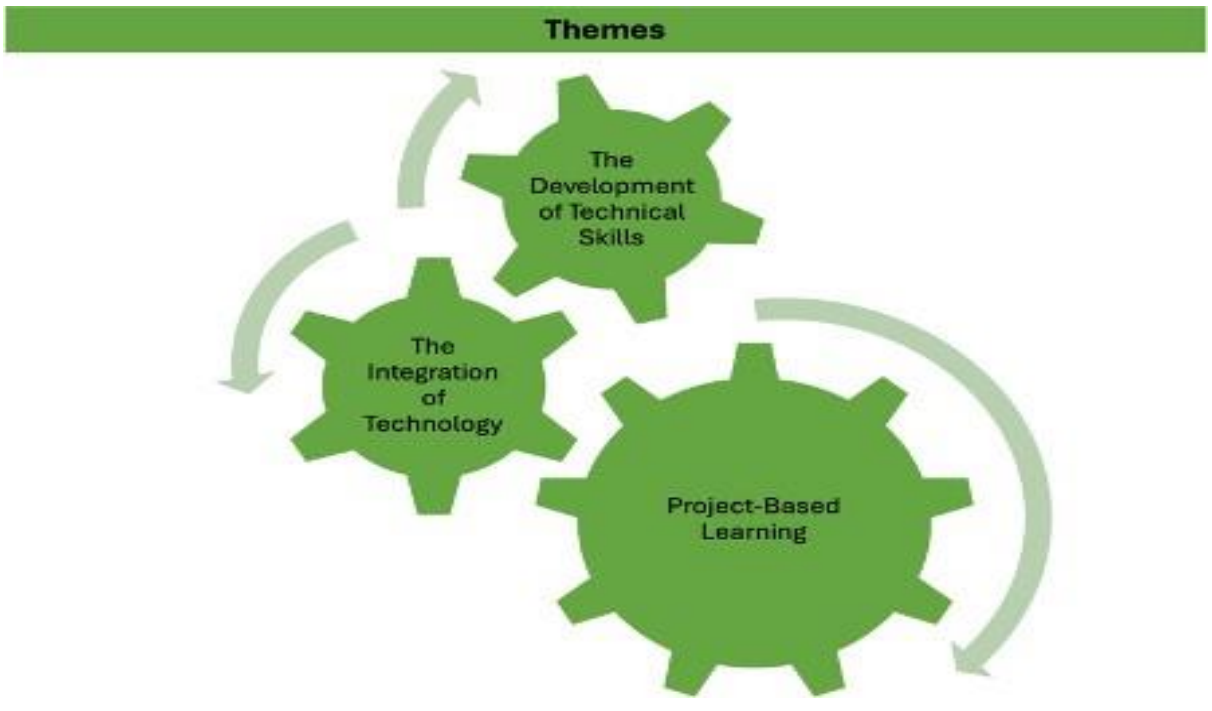


Fig 3. Synthesis themes of Visualization Skills and Patternmaking in Fashion Education by Previous Research

CONCLUSION

In conclusion, this systematic literature review provides valuable insights into the current landscape of patternmaking education within fashion higher education. By applying the Self-Determination Theory (SDT) lens, we have examined the strategies employed to enhance students' visualization skills and delved into the psychological aspects of satisfaction and frustration in the learning process. Through our exploration, it becomes evident that addressing the psychological needs of students is integral to fostering a conducive learning environment. Understanding the role of autonomy, competence, and relatedness in education enables instructors to develop more effective teaching strategies for patternmaking, ultimately fostering better student engagement and learning outcomes. When students feel a sense of autonomy, they are more motivated to take ownership of their learning. Competence, on the other hand, ensures that they develop the necessary skills and confidence to master patternmaking techniques. Relatedness, which refers to the sense of connection between students, peers, and instructors, further enhances the learning environment by promoting collaboration and support.

Additionally, this review highlights the wide range of research methodologies, assessment tools, and linguistic factors that influence studies in this field. The diversity of approaches reflects the evolving nature of patternmaking education, where different contexts, student needs, and institutional resources shape research designs. However, this variability also challenges ensuring consistency and comparability across studies. Therefore, establishing standardized research frameworks and fostering collaboration among scholars are crucial for strengthening the validity and reliability of findings. By working together, researchers can develop more cohesive methodologies that advance knowledge in patternmaking education. This diversity underscores the need for standardization and collaboration among researchers to ensure the validity and reliability of findings.

Furthermore, identifying antecedents and outcomes of satisfaction and frustration elucidates the multifaceted nature of the patternmaking learning experience. From the intricacies of technical skill acquisition to the socio-emotional dynamics within the classroom, our review underscores the complexity of this domain and the importance of holistic support mechanisms (Nassar et al., 2021). Educators and institutions must embrace adaptation strategies catering to students' needs. By fostering resilience, self-awareness, and adaptive coping mechanisms, we can empower students to navigate the challenges of patternmaking education with confidence and efficacy. In essence, this review not only consolidates existing knowledge but also paves the way for future advancements in the field (Burns, 2022). As Lin (2023) mentioned, embracing a human-centric approach and fostering a culture of innovation and collaboration can ensure that fashion education remains at the forefront of pedagogical excellence.

LIMITATIONS AND RECOMMENDATIONS

Efforts to include a wide range of literature on patternmaking education may have inadvertently omitted certain studies, particularly those published in non-English languages or housed within specialized academic databases. Research published in non-English sources may offer valuable insights into region-specific teaching methodologies and challenges, but language barriers and limited accessibility could have restricted their inclusion. Additionally, niche databases that focus on fashion education, vocational training, or industry-specific research may contain relevant studies that were not captured within mainstream academic search engines. Another challenge is the variability in study quality, as some research may rely on small sample sizes, subjective assessments, or non-standardized methodologies. Studies with limited participant numbers may not provide results that can be generalized across broader populations, making it difficult to draw universally applicable conclusions. Additionally, the use of qualitative or self-reported data, while insightful, may introduce biases or inconsistencies in measuring the effectiveness of visualization skills in patternmaking education.

Furthermore, cultural and contextual differences among the reviewed studies pose another limitation in applying findings to various educational environments. Teaching methodologies, institutional structures, and student demographics differ across regions, influencing how patternmaking is taught and learned. These variations make it challenging to develop a one-size-fits-all approach to improving patternmaking education. As noted by Shen

(2024) and Hansen and Andersen (2013), addressing these limitations requires the adoption of more rigorous research methodologies, including larger and more diverse sample sizes to improve the reliability and applicability of findings. Cross-cultural studies can further enrich the understanding of how cultural factors influence the effectiveness of different patternmaking education approaches. By comparing teaching strategies across diverse educational systems, researchers can identify best practices that can be adapted to different learning environments.

Aligning pedagogical innovations with Self-Determination Theory (SDT) principles, as suggested by Jiang (2023), can enhance learning experiences by fostering students' intrinsic motivation, autonomy, and sense of competence in patternmaking education. Additionally, continuous professional development opportunities for educators are crucial in equipping them with the latest teaching techniques, technological advancements, and student engagement strategies. Lastly, establishing robust student feedback mechanisms is essential for refining curriculum design and instructional approaches. Regular input from students can help educators identify areas for improvement and tailor learning experiences to meet evolving educational and industry needs. By implementing these strategies, future research and educational practices can contribute to a more standardized, effective, and culturally adaptable approach to patternmaking education.

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Conflicts of Interest

The authors declare they have many conflicts of interest to report regarding this study, especially in the article database search. The leading cause is the lack of research in Visualisation Skills and Patternmaking in Fashion Education.

REFERENCES

1. Adar, E., & Lee-Robbins, E. (2023). Roboviz: A Game-Centered Project for Information Visualization Education. IEEE Transactions on Visualization and Computer Graphic. vol. 29, no. 1, 2023, doi: 10.1109/TVCG.2022.3209402.
2. Adaboh, S., Akpalu, R., Owusu-Darko, I., & Boateng, S. S. (2021). Using Courseware Instruction to Improve Junior High School Students' Spatial Visualization Skills. International Electronic Journal of Mathematics Education. vol. 12, no. 3, 2021, doi: 10.29333/iejme/617.
3. Al-Shanfari, L., Baber, C., & Demmans Epp, C. (2017). Student preferences for visualizing uncertainty in open learner models. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), doi: 10.1007/978-3-319-61425-0_37.
4. Appiah, N. A. (2023). Higher Fashion Education in Perspective: The Effects of Work-Based Learning on Industry Requirements. British Journal of Multidisciplinary and Advanced Studies. vol. 4, no. 3, 2023, doi: 10.37745/bjmas.2022.00206.
5. Arana, C., Franco, I. B., Joshi, A., & Sedhai, J. (2020). Life on Land A Review of Sustainable Fashion Design Processes: Upcycling Waste Organic Yarns. Actioning the Global Goals for Local Impact: Towards Sustainability Science, Policy, Education and Practice, vol. 1, no. November, 2020.
6. Bach, B., Keck, M., Rajabiyazdi, F., Losev, T., Meirelles, I., Dykes, J., Laramee, R. S., AlKadi, M., Stoiber, C., Huron, S., Perin, C., Morais, L., Aigner, W., Kosminsky, D., Boucher, M., Knudsen, S., Manataki, A., Aerts, J., Hinrichs, U., Roberts, J. C., & Carpendale, S. (2024). Challenges and opportunities in data visualization education: A call to action. IEEE Transactions on Visualization and Computer Graphics, vol. 30, no. 1, 2024, doi: 10.1109/TVCG.2023.3327378.
7. Bednall, A. (2019). Re-Make, Re-Model, Re-define: Fashioning a Nation's Identity. Patternmaking History and Theory, 2019. doi: 10.5040/9781350062672.ch-010.
8. Bishop, F., Zagermann, J., Pfeil, U., Sanderson, G., Reiterer, H., & Hinrichs, U. (2020). Construct-A-Vis: Exploring the free-form visualization processes of children. IEEE Transactions on Visualization and Computer Graphics, vol. 26, no. 1, 2020, doi: 10.1109/TVCG.2019.2934804.

9. Burns, A, (2022). Rethinking Fabric: The Application of Fabric Manipulation Techniques in Fashion Design Education," International Journal of Art and Design Education. vol. 41, no. 1, 2022, doi: 10.1111/jade.12375.
10. Coneybeer, J., O'Brien, E., Hurst, B., & Payne, A. (2023). Assessing the self-regulation strategies and reflexive capacity of fashion companies anti-slavery tools. Australian Journal of Human Rights, vol. 29, no. 2, 2023, doi: 10.1080/1323238X.2023.2290770.
11. Conlon, J., & Gallery, C. (2024). Developing digital skills: a fashion business masterclass in virtual 3D prototyping with Style3D. International Journal of Fashion Design, Technology and Education, vol. 17, no. 1, 2024, doi: 10.1080/17543266.2023.2247425.
12. Conlon, J. (2021). Using product lifecycle management (PLM) to re-think fashion business education: an assessment of pedagogical practices and learning benefits. Research Journal of Textile and Apparel. vol. 28, no. 2, 2024, doi: 10.1108/RJTA-10-2021-0128.
13. Farrer, J., & Finn, A. (2010). The power of a single prototype: Sustainable fashion textile design and the prevention of carcinogenic melanoma. Innovative Developments in Design and Manufacturing - Advanced Research in Virtual and Rapid Prototyping.
14. Figgess, G., & Fogarty, J. (2018). Visualization Skills and Student Success in Engineering Disciplines. Proceedings - Frontiers in Education Conference, FIE. doi: 10.1109/FIE.2018.8659214.
15. Finn, A., & Fraser, K. (2012). Contemporary Classrooms: Exploring Blackboard Academic Suite (Tm) And Virtual Teaching Spaces for Fashion Education. Edulearn12: 4th International Conference on Education and New Learning Technologies.
16. Hansen, R., & Bjørn-Andersen, N. (2013). Cube assessment framework for B2C websites applied in a longitudinal study in the luxury fashion industry. Journal of Theoretical and Applied Electronic Commerce Research, vol. 8, no. 2, 2013, doi: 10.4067/S0718-18762013000200002.
17. Hutton, B., Salanti, G., Caldwell, D. M., Chaimani, A., Schmid, C. H., Cameron, C., Ioannidis, J. P. A., Straus, S., Thorlund, K., Jansen, J. P., Mulrow, C., Catalá-López, F., Gøtzsche, P. C., Dickersin, K., Boutron, I., Altman, D. G., & Moher, D. (2015). The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: Checklist and explanations. Annals of Internal Medicine, 162(11), 777–784.
18. Ildephonse, N. (2023). Overview of Textile and Fashion Higher Education in Burundi. 2023. doi: 10.1007/978-981-99-1320-6_4.
19. Jiang, M. (2023). The Impact and Potential of Educational Technology: A Comprehensive Review," Research and Advances in Education, vol. 2, no. 7, 2023, doi: 10.56397/rae.2023.07.05.
20. Kim, S., & Kim, H. Y. (2022). Creative exploration: zero-waste fashion design practices with traditional Korean clothing. International Journal of Fashion Design, Technology and Education, vol. 16, no. 2, 2023, doi: 10.1080/17543266.2022.2148293.
21. Kösa, T., & Karakuş, F. (2017). The effects of computer-aided design software on engineering students'spatial visualisation skills. European Journal of Engineering Education, vol. 43, no. 2, 2018, doi: 10.1080/03043797.2017.1370578.
22. Lin, X. (2023). Fashion Design Education: A Study of Fashion Design Educational Systems of Italy and China. Design Principles and Practices. vol. 17, no. 1, 2023, doi: 10.18848/2325-128X/CGP/v17i01/199-212.
23. Mnguni, L., Schönborn, K., & Anderson, T. (2016). Assessment of visualisation skills in biochemistry: Students. South African Journal of Science, vol. 112, no. 9–10, 2016, doi: 10.17159/sajs.2016/20150412.
24. Mohamed Shaffril, H. A., Ahmad, N., Samsuddin, S. F., Samah, A. A. &. Hamdan, M. E. (2020). Systematic literature review on adaptation towards climate change impacts among indigenous people in the Asia Pacific regions. Journal of Cleaner Production, vol. 258. 2020. doi: 10.1016/j.jclepro.2020.120595.
25. Moleko, M. M. (2021). Teachers' Perspectives on Addressing Linguistic Factors Affecting Visualisation of Mathematics Word Problems. Eurasia Journal of Mathematics, Science and Technology Education, vol. 17, no. 11, 2021, doi: 10.29333/ejmste/11248.
26. Moore, J. G. (Ed.). (2019). Patternmaking history and theory. Bloomsbury Visual Arts. doi: 10.5040/9781350062672.
27. Nassar, A. K., Al-Manaseer, F., Knowlton, L. M., & Tuma, F. (2021). Virtual reality (VR) as a simulation modality for technical skills acquisition. Annals of Medicine and Surgery, vol. 71. 2021. doi:

10.1016/j.amsu.2021.102945.

28. Park, J., Kim, D. E., & Sohn, M. H. (2011). 3d simulation technology as an effective instructional tool for enhancing spatial visualization skills in apparel design. International Journal of Technology and Design Education. vol. 21, no. 4, 2011, doi: 10.1007/s10798-010-9127-3.
29. Pongo, N. A., Asare, T. O., & Abdul-Fatahi, I. (2015). Evaluation of the Challenges of 21st Century on Quality Assurance of Higher Fashion Education in Ghana. ISSN, vol. 29, 2015.
30. Pushkareva, N. L., & Mitsyuk, N. A. (2017). Modernization of the early childhood material culture in the Russian nobility families of the second half of the 19th - Early 20th century. Ural'skij Istoriceskij Vestnik, vol. 54, no. 1. 2017.
31. Saeed, A., Foaud, L., & Fattouh, L. (2017). Techniques used to Improve Spatial Visualization Skills of Students in Engineering Graphics Course: A Survey. International Journal of Advanced Computer Science and Applications, vol. 8, no. 3, 2017, doi: 10.14569/ijacsa.2017.080315.
32. Shen, D. (2024). An Empirical Study on Consumer Awareness of Sustainable Fashion: A Longitudinal Approach. International Journal of Sustainability in Economic, Social, and Cultural Context. vol. 20, no. 1, 2024, doi: 10.18848/2325-1115/CGP/v20i01/19-45.
33. Thorisdottir, T. S., & Johannsdottir, L. (2020). Corporate social responsibility influencing sustainability within the fashion industry. A systematic review. Sustainability (Switzerland), vol. 12, no. 21. 2020. doi: 10.3390/su12219167.
34. Tsarouchis, S. F., Vartholomaios, A. S., Bountouridis, I. P., Karafyllis, A., Chrysopoulos, A. C., & Mitkas, P. A. (2021). Science4Fashion: An Autonomous Recommendation System for Fashion Designers. IFIP Advances in Information and Communication Technology, doi: 10.1007/978-3-030-79150-6_57.
35. Yang, S., Song, Y., & Tong, S. (2017). Sustainable retailing in the fashion industry: A systematic literature review. Sustainability (Switzerland), vol. 9, no. 7. 2017. doi: 10.3390/su9071266.
36. Xing, X., Li, L., & Xu, C. (2022). Studies on the traditional embroidery consumer market segmentation and characteristics based on fashion value perception. Journal of Silk, vol. 59, no. 1, 2022, doi: 10.3969/j.issn.1001-7003.2022.01.011.
37. Xing, Y. M., Wang, Z. J., Tao, X. Y., Zeng, X. Y., Wang, J. P., & Bruniaux, P. (2022). Blended Learning Outcome Evaluation in Fashion Higher Education Using Artificial Neural Network Technique. Textile Bioengineering and Informatics Symposium Proceedings 2022 - 15th Textile Bioengineering and Informatics Symposium, TBIS 2022, 2022.