A Novel Educational Tool to Advance Current Fashion Pattern Construction Practices: A Theory-Based Design Process and Learner-Centric Pilot Evaluation

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Abstract

Pattern parametrisation offers notable advantages over traditional methods in efficiency, sustainability, and creativity, yet remains underutilised due to limited awareness and mastery of its conceptual and technical foundations. This study adopted a developmental instructional design approach to create PatternInstruction, an LMS-based OER platform promoting the adoption of the generic frameworks established by Gill et al.(2023) for flexible integration across fashion contexts. Its development followed the theory-informed OER-PattEdu instructional design model established by Al Houf et al. (2024), designed to support the dissemination of fashion pattern construction innovations (FPCIs). A post-learning mixed-method evaluation assessed PatternInstruction's usability and impacts on the adoption process before large-scale implementation. Findings confirmed its effectiveness and readiness to support widespread adoption. The study contributes theoretically by demonstrating how open LMS-based OERs can be developed and piloted to disseminate field-specific innovations, and methodologically by operationalising and evaluating the OER-PattEdu model for the first time. Engaging practitioners through PatternInstruction offers the potential to shift both academic and industrial practices towards a more efficient, sustainable, and creative engineering paradigm.

Keywords: *pattern construction, pattern parametrisation, LMS-based OERs, learner-centric pilot evaluation.*

1. INTRODUCTION

FPC is the foundational and most critical stage in garment manufacturing, transforming abstract design and body-to-pattern theories into wearable outcomes [3]. It involves creating 2D blueprints aligned with the 3D human form by integrating geometry, anatomy, style, and fit principles[4]. It is a complex, iterative process that requires advanced theoretical and technical expertise to ensure precision and functionality [1], [3]. As such, it has evolved into a specialised area within fashion education to support the transmission of its essential knowledge base[4]. Over time, traditional FPC methods, still widely taught and employed in academia and industry, have faced increasing criticism for inefficiency, lack of sustainability, limited design exploration, and failure to meet the growing demand for highly customised patterns[1], [2]. These paper-based and sketch-based digital methods produce static outputs and rely on trial and error to achieve customisation, consuming significant time, energy, and material resources [1]. This limits their capacity to integrate innovation, precise fit, aesthetic design, and resource-conscious practices [5]. Pattern parametrisation addresses the limitations of traditional methods by linking pattern outputs to dynamic inputs, such as anthropometric data, style requirements, and user preferences, enabling responsive and adaptable outputs[1]. This facilitates efficient reusability, resizability, alteration, and customisation without recreating patterns from scratch; adjustments to input data trigger automatic software modifications, reducing paper, energy, and effort waste, thus significantly enhancing sustainability and efficiency in patternmaking [1], [2]. Despite its documented benefits and long-standing integration into CAD systems, traditional methods continue to dominate fashion practice and education, and the adoption of pattern parameterisation remains limited [1], [2]. This limited uptake is primarily due to the absence of generic theoretical and technical frameworks that unify its core principles and support

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adaptation across fashion contexts and CAD systems [1]. Existing research tends to contextualise parameterisation within specific technologies or domains, such as textiles, fit, or software development, restricting its transferability[6], [7]. Gill et al. (2023) established generic frameworks for pattern parameterisation, independent of specific tools or contexts, enabling adaptation across fashion applications using accessible parametric CAD systems. Al Houf et al. (2024) developed the OER-PattEdu model to guide the creation of LMS-based OERs for disseminating such innovations. Building on this, the present study developed and evaluated PatternInstruction, an open LMS-based OER embedding Gill et al.'s frameworks using the OER-PattEdu model. PatternInstruction is the first tool to operationalise these frameworks, supporting practitioners in adapting pattern parameterisation across contexts and advancing their practices. This work lays the foundation for future collaborations with educational and industry stakeholders to scale adoption across academia and the fashion sectors.

2. LITERATURE REVIEW

2.1. Pattern Parametrisation Potential to Advance Current Pattern Practice

Pattern parametrisation has the potential to significantly advance both academic and industry practices. In academia, pattern parametrisation offers a valuable experimentation tool for fit researchers investigating drafting methods [1], [7]–[9], formulas, geometric rules and instructions that detail how measurements, ease allowance and style requirements can be applied to patterns, accounting for the relationship between the body and the pattern and fabric attributes [4], [10]. Fit researchers extensively develop and test proposals to refine fit theories and evolve existing drafting methods to enhance this body-pattern relationship [1], [7]–[9], [11]–[13]. This process requires a construction approach that provides a dynamic workflow and a responsive experimentation system to enable efficient change applications and immediate observation of their outcomes [14], [15]. However, the traditional construction approach, which currently dominates academia, does not facilitate this level of experimentation [1], [8]. It produces static patterns that lack the flexibility needed for iterative experimentation, often requiring complete redrafting from scratch [1], [16], [17]. This renders the traditional approach inefficient for research activities, as it is time and effort-consuming and unsustainable due to the significant consumption of paper and energy [1], [16], [17].

In contrast, pattern parametrisation has demonstrated its value as an efficient and sustainable experimentation approach [1], [7]–[9], [11], [12]. It allows researchers to create dynamic tables defining all variables that impact pattern style and fit, such as body anthropometric data, style requirements, fabric attributes, and personal preferences [9], [18]–[21]. Researchers can modify, adjust, or even interconnect these variables and their values dynamically, and the software applies these changes to the pattern automatically. Thus, researchers can observe the impacts of these changes immediately, which greatly facilitates the sustainable and efficient examination of each variable's impact on the pattern fit and style [1], [7], [12], [21]. This approach enables researchers to identify fit issues and areas impacted by them and develop solutions efficiently [1], [9]. In addition, pattern parametrisation enables establishing linkages between the dynamic input variable table and the pattern [13]. This linkage provides a dynamic workflow and a responsive experimentation system that significantly streamlines the experimentation process by enhancing speed and accuracy, reducing effort, and improving sustainability through optimised resource use [1]. This linkage also motivates more systematic and analytical thinking during the construction process, leading to a greater theory-underpinned structure and a stronger body-to-pattern relationship [22].

Importantly, pattern parametrisation supports garment engineering by offering geometric tools that enable the construction of proportional, cohesively structured and well-fitting patterns that reflect body shape, size, and individual needs. These tools, like perpendiculars, referencing and symmetry tools, also enable the establishment of stronger interconnections between the pattern's components (Gill et al., 2023). These advantages collectively address the limitations of the traditional approach for research activities and meet the requirements of efficient, accurate, and sustainable fit experimentation practices.

Regarding Industry, the garment production model has increasingly shifted from mass production to customisation due to the rising demand for greater personalisation in garment styles, comfort, and fit (Tao *et al.*, 2018; Zhou *et al.*, 2021; Jin *et al.*, 2023). The key challenge facing customisation is how to produce garments in various sizes economically and efficiently [14]. This is because the current traditional construction and customisation approach widely adopted within the fashion industry poses significant challenges, including high time costs, labour demands, and resource wastage associated with pattern recreation and manual alteration and customisation[7], [14].

Therefore, this shift to customisation necessitates adopting new approaches that facilitate effective, efficient, and sustainable pattern construction and customisation. Pattern parametrisation holds considerable potential for advancing traditional construction and customisation practices by enabling the creation of bespoke patterns customised to customers' individual body requirements and personal fit and style preferences [7], [14], [24]. While constructing parametric patterns is more time and effort-consuming than the traditional approach, it generates a foundational responsive block that can be efficiently and sustainably customised for an unlimited number of customers by simply adjusting the variable values in the dynamic variable table [1], [7]. The advantages of pattern parametrisation align not only with the requirements for efficient customisation but also with the increasing demand for sustainable and environmentally friendly practices within the fashion industry.

Gill et al. (2023) established generic frameworks for pattern parametrisation to provide a unified understanding of its conceptual and technical principles and their potential to advance the current pattern practices and enable their adaptation to different contexts, including fashion design, textile engineering and fashion technologies. These frameworks are not tied to specific technologies, making them applicable to any accessible parametric CAD system. This study built upon Gill et al.'s (2023) work by embedding these frameworks into a novel educational tool. Specifically, it designed and conducted a learner-centred pilot of this tool as part of a future educational initiative aimed at enhancing the widespread adoption of pattern parametrisation and driving a real-world shift in the fashion industry and academia towards more efficient, sustainable, and advanced paradigms.

2.2. The OER-PattEdu Model

The OER-PattEdu model, developed by Al Houf et al. (2024), is a specialised instructional design model for creating, evaluating, and implementing open LMS-based OERs to promote FPCI adoption. It integrates TAM with constructive and experiential learning strategies to enhance PU, and bite-sized, multimedia, scaffolding, and concept mapping strategies to improve PEOU. This study represents the first application and evaluation of the model, assessing both technical usability and its influence on adoption intention.

2.3. Usability Evaluation of Open LMS-Based OERs

Usability evaluation of open LMS-based OERs concerns their learnability and technical functionality, essential to supporting adoption [8]. Ensuring these aspects before full-scale implementation is vital, as technically poor tools undermine behavioural intentions toward adoption [25]. Two standard evaluation methods are commonly applied; expert-centred evaluation involves usability inspection by instructional design experts using predefined criteria [26], typically applied to early prototypes. In contrast, user-centred evaluation engages end-users in piloting the final version, with technical usability assessed through quantitative surveys[27]–[29]. However, the success of an LMS ultimately relies on its accessibility and usability for end users [27]. Accordingly, this study adopts a user-centred approach to evaluate the technical usability and learnability of PatternInstruction. It contributes to the literature by examining the applicability of established multidisciplinary usability evaluation methods to open LMS-based OERs in FPC.

2.4. Instructional Design Quality Evaluation of Open LMS-Based OERs

Evaluating the instructional design quality of e-learning tools provides formative insights into their potential to support adoption[2]. This can be conducted through expert-centred reviews assessing content relevance or user-centred evaluations involving target learners [30]. The expert-centred method focuses on evaluating the validity of the learning content and its relevance to the industry, whereas the user-centred method examines the impact of the instructional tool prototype on adoption [30]. Given that content validity has already been addressed in Gill et al. (2023), the present study adopted a user-centred approach to investigate the impacts of *PatternInstruction* design on learning effectiveness and perceived value in promoting pattern parametrisation and to identify design limitations requiring revision before full-scale implementation. This study contributes to the existing body of knowledge by conducting a formative evaluation of instructional design quality within the context of open LMS-based OERs for FPC.

3. METHODS

3.1. Research Design, Tools, Sampling, and Ethics

This study employed an instructional design-based developmental approach to create PatternInstruction, following the structured phases and procedures of the selected IDM, as commonly applied in related research [31]–[33]. A post-use mixed-method evaluation was conducted. The usability survey, adapted from Murphrey et al. (2023) and Suria (2024), used a 5-point Likert scale to assess elements such as navigation, content, visuals, audio, supporting documents, and feedback mechanisms, factors identified as critical to shaping user perceptions and adoption of online learning content [28]. Quantitative data were analysed descriptively using percentages and frequencies, following the traditional analytical approach in relative research [28], [29]. Semi-structured interviews, based on questions adapted from Hodges et al. (2020), explored the design's potential impact on adoption. Thematic analysis of qualitative data was guided by the theories and design strategies underpinning the OER-PattEdu model. This study employed a convenience sample comprising 38 UK-based learners, generally deemed sufficient for piloting purposes [32], [33], [37]. This study was conducted under the approval and supervision of The University of Manchester's Institutional Review Board.

3.2. The Development and Pilot of PatternInstruction

This process followed the phases and procedures of the OER-PattEdu model, as detailed below.

Phase 1: Analysis

An in-depth literature review was conducted to identify knowledge gaps and inform instructional aims. The analysis revealed a lack of generic conceptual and technical frameworks for pattern parameterisation, hindering its adaptability across diverse FPC technologies and contexts, and thus limiting adoption despite its advantages over traditional methods. In response, two instructional aims were set: (1) to establish these frameworks comprising geometric data entry, workflow, construction space, and outputs, and (2) to develop and pilot a tool embedding them to support future initiatives to enhance its widespread adoption.

Phase 2: Design

This phase designed and piloted the generic conceptual and technical, see Gill et al. (2023). It also designed and validated a methodological framework to support their large-scale dissemination and evaluate users' behavioural intention to adopt them, see Al Houf et al.(2024).

Phase 3: Development

The frameworks were segmented into bite-sized, multimodal units, complex processes were visualised in concept mapping, and the technical knowledge was delivered through scaffolded, step-by-step tutorials designed to facilitate comprehension and demonstrate usefulness, as outlined in Table 1 :

Table 1. Breakdown of instructional content units and corresponding tutorial activities

Component	Content and Corresponding Tutorials
Overview	Defines pattern parameterisation technically and conceptually. Highlights its advantages and applications for professionals and academics. **Tutorial:** Customising ready parametric patterns on Seamly2D to illustrate the conceptual and technical definitions.
Entry Methods	Introduces pattern-specific geometric data entry methods distinct from traditional approaches. Explains how to segment patterns into geometric variables (e.g., measurements, ease allowances, body dimensions) for control and engineering. **Tutorial:** Using Seamly2D's measurement application to set up and save measurement files for Aldrich and G-Block skirts, demonstrating variable creation and management.

Construction space	Examines coordinate systems essential for parametrising fashion patterns. Highlights their role in enhancing construction accuracy and spatial control. Introduces the input-to-output linkage mechanism for responsive customisation. **Tutorial:** Creating draft sheets and explaining coordinate tools on Seamly2D in a technology-agnostic way, linking inputs to outputs in Aldrich skirt patterns.
Constructio n Workflow	Explains the dynamic, iterative construction workflow unique to pattern parameterisation, contrasting it with static traditional workflows. Encourages experimentation and creativity. **Tutorial**: Parametrising Aldrich and GBlock-001 patterns to demonstrate flexibility and creativity in construction processes (ADE.Manchester, 2022).
Constructio n Outputs	Highlights the responsive, dynamic nature of parametric outputs, focusing on accuracy, efficiency, and proportional scalability. **Tutoria**l: Customising Aldrich and G-Block patterns for various customers on Seamly2D to evaluate output responsiveness and functional scalability.

Phase 4: Implementation

This phase involved recruiting participants after obtaining ethical approval and engaging them with PatternInstruction. Post-engagement feedback was then collected to evaluate its usability and the instructional design's potential impact on the adoption process.

Phase 5: Evaluation

This phase analysed data to evaluate PatternInstruction's usability and the influence of its design on the adoption of pattern parametrisation. It also aimed to identify improvements before full-scale implementation.

Phase 6: Use

This phase utilised the pilot evaluation results to inform evidence-based improvements to PatternInstruction before large-scale implementation. Additionally, the findings contributed to this developmental and pilot study, published to guide future research methodologies and advance this area.

4. FINDINGS AND DISCUSSION

4.1. Sample Analysis

Among the 38 participants, 30 (79%) were female, and 8 (21%) were male, reflecting the predominance of women in the pattern construction field. This finding aligned with UK industry statistics and historical records, which report that women comprise over 70–80% of the UK garment manufacturing workforce [4], [38]–[40]. This further indicates that the pilot study's findings were influenced by the experiences and preferences of the field's majority demographic. The research sample consisted of participants from both fashion-related and non-fashion-related academic backgrounds. Fashion-related disciplines included fashion technology, fashion and textiles, fashion design, apparel, textile engineering, and textile technology. This diversity highlighted the critical role of pattern construction across various fashion subsectors and the potential benefits of pattern parametrisation within them, as supported by previous studies [8], [41], [42]. In the context of the pilot test, feedback from such academically diverse users provided valuable insights into how effectively PatternInstruction aligned with the technical and pedagogical expectations of both industry and academia. Non-fashion-related fields represented in the sample included dermatology, chemistry, mechanical engineering, and medical laboratory sciences. This group comprised hobbyists from the broader public community engaged in fashion homemaking and seeking specialised knowledge. These findings validated the open educational approach employed in this study for disseminating pattern parametrisation and reinforced the importance of an open educational paradigm that democratises knowledge and expertise, as advocated by Haleem *et al.* (2022), Wu *et al.* (2023), Bertola (2018), Sanabria and Arámburo-Lizárraga (2017), and Bertola and Vandi (2020). Piloting PatternInstruction with participants unfamiliar with pattern construction provided fresh, objective perspectives on its usability and accessibility. Their ability to comprehend its content and navigate it demonstrated its clarity and user-friendliness for novices or individuals without prior experience in pattern construction. The sample comprised fifteen students, six academics (three lecturers and three researchers), five non-fashion professionals who were fashion hobbyists, seven professional pattern cutters, and five fashion designers. This diverse composition facilitated a multiperspective evaluation of PatternInstruction's content and user experience. Students and academics provided critical feedback on its pedagogical and theoretical dimensions, ensuring alignment with educational objectives, while professionals offered insights into its potential to enhance industry practices. Hobbyists, meanwhile, assessed PatternInstruction from a non-specialist perspective, reflecting the experiences of beginners in pattern construction. However, the predominance of students in the sample may have skewed the findings towards the needs of this demographic, an important consideration when interpreting the results. Participants' experience in pattern construction ranged from none to eight years, significantly influencing this pilot study's outcomes. Those with more experience provided nuanced insights into PatternInstruction's value and potential to refine traditional practices in the field. Conversely, less experienced participants and novices offered perspectives on its ability to provide the concepts and skills of parametric pattern construction for future professionals. This diversity in experience ensured a balanced evaluation, which was necessary to address the needs of both seasoned professionals and newcomers to pattern construction.

4.2. Analysis of Data on PatternInstruction's Usability

Usability data were analysed descriptively. The results, expressed as frequencies (f) and percentages (%), are summarised in Table **2**.

Table 2. Descriptive analysis of usability data

Usability Criteria	**Level of Agreement** *n*= 38									
	SA		**A**		**NAD**		**D**		**SD**	
	f	***%***	***f***	***%***	***f***	***%***	***f***	***%***	***f***	***%***
PatternInstruction was technically accessible.	33	86.842	5	13.157	0	0	0	0	0	0
PatternInstruction was easy to navigate.	31	81.576	7	18.421	0	0	0	0	0	0
PatternInstruction was functionally consistent.	35	92.105	3	7.894	0	0	0	0	0	0
Videos played without technical issues.	30	78.947	8	21.052	0	0	0	0	0	0
The audio functioned correctly and was easy to understand.	33	86.842	5	13.157	0	0	0	0	0	0
Video content effectively explained the topic.	32	84.210	6	15.789	0	0	0	0	0	0
The visuals were high-resolution and visually appealing.	30	78.947	8	21.052	0	0	0	0	0	0
The texts were clear and easy to read.	33	86.842	5	13.157	0	0	0	0	0	0
Supporting documents were downloadable and usable.	32	84.210	6	15.789	0	0	0	0	0	0
I was able to locate and access documents from earlier videos when needed.	37	97.368	1	2.631	0	0	0	0	0	0
I submitted my feedback without technical issues.	30	78.947	8	21.052	0	0	0	0	0	0
Total	38 participants (100%).									

The results indicate high usability scores. Most participants strongly agreed with the platform's technical accessibility, navigability, functional consistency, clarity of content, and the resolution of audio and visual elements. The lowest score recorded was 78.95%, while the generally acceptable average usability score is approximately 70.09 [29], [48]. No participants expressed neutrality or disagreement across any of the criteria. This would suggest well-received usability, affirming PatternInstruction's effectiveness in providing a user-friendly learning experience and emphasising its potential to enhance user engagement and satisfaction.

4.3. Analysis of Data on the Impacts of PatternInstruction's Design on the Adoption

Qualitative analysis of PatternInstruction's theory-informed design indicated positive impacts on learning acquisition and adoption. Students emphasised features that enhanced ease of use, whereas professionals highlighted its usefulness in advancing their professional practice. Table 3 provides exemplary quotations from participants' feedback, linked to their professional roles.

Table 3. Participants' Feedback on the Design Impacts

Design Underpinning Theories Enhancing Perceived Usefulness		
Design Theory	**Feedback Provider**	**Exemplary Quotation**
Experiential Learning	Fashion Designer	"Honestly, when the learning started, I found parameterisation complex and thought resizing patterns manually was easier, but once I parametrised the skirt patterns and adjusted them quickly and easily for different sizes, I realised how much time it saves and how flexible it makes my work."
Constructive Learning	Bespoke Pattern Cutter	"Altering patterns is the main benefit. I tried various methods with limited success, including paper, pen, and draping, but there were still errors. This tech enables me to create slopers with formulas that can be scaled proportionally to fit multiple sizes. It is amazing to make a base pattern and then modify it into countless styles with the computer."
Design Underpinning Theories Enhancing Perceived Ease of Use		
Design Theory	**Feedback Provider**	**Exemplary Quotation**
Bite-Sized Learning	Fashion Design Student	"Videos were short, concise, and explained step-by-step. This made it easy to digest, understand, and absorb knowledge without frustration."
Scaffolding Learning	Fashion and Textile Student	"The learning materials were straightforward to follow. They were broken into steps, progressing from simpler concepts to more complex ones. This made the content manageable."
Multimedia Learning	Fashion Technology Student	"Listening to the verbal instructions while watching them applied to Seamly2D helped me understand and do pattern parameterisation."
Concept Mapping	Textile Engineering Student	"When looking at the motion diagram, I briefly understood the elements of parameterisation, their functions, and interrelationships. Seeing them all at once kept them simultaneously in my mind"

These quotes demonstrate PatternInstruction's potential to promote the adoption of pattern parametrisation
and support the shift from traditional to parametric pattern construction. However, participants noted its limited scope, as it included only two modules focusing on skirt patterns. They called for additional resources covering other pattern blocks, such as sleeves and bodices. A design lecturer commented, "*One aspect I would like to see improved is the inclusion of more tutorials on other patterns, such as bodice and sleeves, to make PatternInstruction more beneficial.*" Nevertheless, PatternInstruction was primarily designed to impart the conceptual knowledge and practical skills of pattern parametrisation, highlight its benefits for diverse users, guide the replacement of conventional manual and digital methods, and illustrate the practical differences between parametric and traditional approaches through real-world applications. Mastering skirt pattern parametrisation equips users to parametrise other patterns since skirts incorporate all geometric elements needed and follow the same principles.

5. Conclusion, Contributions and Implications

Pattern parametrisation presents considerable potential to reform traditional FPC by addressing its inefficiencies and unsustainability while enabling engineered outputs. Nonetheless, its broader adoption in academia and industry remains constrained by a lack of adaptable, generic frameworks for diverse FPC parametric technologies and contexts. Gill et al. (2023) began to address this gap by establishing such frameworks; the present study extends their efforts by designing and evaluating PatternInstruction, an open LMS-based OER embedding these frameworks to support future educational initiatives aimed at enhancing the widespread adoption of pattern parametrisation. This study provides a theoretical understanding of how open LMS-based OERs for FPC can be developed and piloted. It also conceptualises the evaluation of usability and instructional design impacts on adoption within this context. The study drew on multidisciplinary educational research to develop and test a user-centred methodology for this evaluation. Findings affirm the value of adopting a mixed-methods approach, integrating qualitative user feedback with quantitative usability metrics, which offers a robust framework for piloting novel LMS-based OERs. It is the first to apply and validate the OER-PattEdu model, demonstrating the usability of its outputs and design impacts on adopting FPCIs. PatternInstruction holds the potential to advance current FPC practices and promote a shift towards a more sustainable, efficient, creative, and engineered future for the fashion industry and academia.

6. Limitations and Recommendations

This study primarily assessed PatternInstruction's usability in terms of technical functionality and learnability, without examining its impact on learners' conceptual or technical performance. Further research is required to explore these outcomes. The sample size was limited to 38 participants, which may affect the generalisability of the findings. Expanding the sample would yield a more comprehensive evaluation of the platform's usability and design quality. The study also did not assess PatternInstruction's capacity to influence actual behavioural change or transform pattern construction practices. Future research should involve institutional and industry collaborations to examine this area. While participants represented a broad spectrum of fashion professions, not all disciplines were included. Subsequent studies should incorporate a wider range of fashion specialisations to evaluate the platform's applicability across diverse contexts.

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