

A case study on integrating 2D vector design and 3D virtual prototyping for traditional Bangladeshi Panjabi development

Abstract

This study investigates the integration of 2D vector design and 3D virtual prototyping for apparel product development using a traditional Bangladeshi men's Panjabi as a case study. Conventional apparel product development can be time- and resource-intensive because multiple physical samples may be required to refine garment design, construction, and fit. The study examines an integrated digital product development process that combines 2D vector design with 3D virtual prototyping to support iterative design development and virtual evaluation before physical sampling. Adobe Illustrator was used to develop the 2D garment design, including fashion flats, design variations, and decorative motifs, while CLO 3D was used for pattern development, virtual garment assembly, visualization, simulation, and virtual fit assessment. The CLO 3D material specification used for the virtual prototype was a woven, 100% silk material with an areal weight of 49.4949 g/m² and a thickness of 0.23 mm. Application of the integrated workflow to the Panjabi demonstrated how the two software environments could support systematic design development, rapid visualization of design alternatives, and virtual evaluation of garment appearance, construction, silhouette, simulated fabric drape, and garment-avatar interaction before physical sampling. The workflow also enabled contemporary visual development while retaining key characteristics of the traditional Panjabi silhouette and decorative treatment. Overall, the case demonstrates the practical feasibility of integrating 2D vector design and 3D virtual prototyping into the early stages of apparel product development, particularly for iterative design refinement and preliminary virtual evaluation of culturally specific garments. The findings indicate potential applications of integrated 2D and 3D digital workflows in Bangladeshi fashion education and apparel product development. However, quantitative comparative studies are required to determine the effects of the workflow on development time, physical sampling requirements, material consumption, and cost.

Keywords: apparel product development, 2D vector design, 3D virtual prototyping, CLO 3D, Bangladeshi Panjabi, silk fabric, digital apparel design

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Introduction

The men's Panjabi is a traditional long shirt worn by men throughout South Asia and is commonly known as a kurta. In Bangladesh, it is a staple element of festive, social, and religious dress and is closely associated with the country's costume heritage and cultural identity.¹ The apparel product development process usually involves several stages, including design development, pattern making, sample preparation, fitting, and final modification, with fit assessment at the center of an iterative sampling process.² These stages can require repeated physical sampling, particularly when changes are needed to garment shape, construction, or fit. Because fit and construction are difficult to predict from a two-dimensional drawing, garments may require several sampling rounds before approval, with each round adding time and expense.³ At the 2D stage of apparel design, Adobe Illustrator can be used to create fashion flats, garment details, motifs, color variations, and other design elements. Technical fashion flats are important for communicating garment concepts and construction details to producers before production because they provide a clear visual representation of the intended design.⁴ Using 2D digital graphics enables seamless adjustment and the creation of design variations without redrawing the entire garment, thereby improving efficiency and reducing labor and time costs.⁵

For this reason, Adobe Illustrator was selected as the primary 2D design environment for developing the Panjabi. The next stage

involved transforming the 2D design into a 3D virtual garment. Three-dimensional virtual prototyping allows designers to visualize a product on a virtual body and explore garment fit and silhouette, fabric drape, and construction before producing a physical sample. Among available digital fashion technologies, CLO 3D provides a practical environment for draping garment patterns on a virtual avatar and evaluating fit before production.^{2,6}

Recent studies suggest that 3D design tools can support the creation of virtual prototypes for testing design ideas before physical prototyping and can facilitate real-time changes, thereby enabling rapid prototyping and flexible design modification.^{3,7} Virtual prototyping also allows designers to make rapid changes and digitally evaluate fabric and pattern behavior, potentially reducing the need for multiple physical samples. Previous research has reported that virtual simulation can reduce sample-development time, decrease the number of physical prototypes required, and reduce material consumption during early product development.^{3,8}

Research on 3D virtual fashion-based garment fitting has likewise suggested that virtual simulation can support faster product development and provide opportunities to evaluate garment fit before physical prototypes are produced.^{6,8} The contribution of this study lies in demonstrating an integrated 2D–3D digital workflow specifically applied to the development of a traditional Bangladeshi men's Panjabi. While previous research has examined digital

prototyping, virtual fitting, and digital preservation of traditional garments separately, comparatively limited attention has been given to the continuity between 2D design development and 3D virtual prototyping for Bangladeshi traditional apparel. The present case therefore provides a practical example of how design exploration, garment visualization, virtual construction, material assignment, and preliminary fit assessment can be connected within a single digital development process.

Research questions

Therefore, the present research is guided by the following questions:

- 1) How can Adobe Illustrator be used to develop and refine the 2D design and fashion flats of a traditional Bangladeshi men's Panjabi?
- 2) How can CLO 3D be used to construct, simulate, and visually evaluate a 3D virtual prototype of the selected Panjabi?
- 3) How does the integration of Adobe Illustrator and CLO 3D support the apparel product development process in the case of a traditional Bangladeshi Panjabi?

Research objectives

The current research aims to achieve the following objectives:

- 1) To develop and refine the 2D design and fashion flats of the selected traditional men's Panjabi using Adobe Illustrator.
- 2) To develop and evaluate a 3D virtual prototype of the selected Panjabi using CLO 3D.
- 3) To examine how the integrated 2D-3D workflow supports design development, virtual evaluation, and decision-making before physical sampling.

Literature review

Conventional apparel product development

The apparel product development process generally involves a series of steps, including design development, pattern making, sample preparation, fitting, and modification before final approval, with visual assessment of fit and silhouette positioned at the center of the iterative sampling process.⁹ Fit and construction are too complex to predict reliably from a two-dimensional drawing.¹⁰ And changes to garment shape, construction, or fit therefore often require a return to the sampling stage. Most garments require multiple sampling cycles before final approval. The prototyping and sampling stages are widely recognized as time-consuming and expensive for apparel firms because each additional sample increases development time, material consumption, and production cost. Research on digital prototyping has likewise identified conventional sample making as a slow process, with substantial time devoted to sample development and approval.³

2D digital design in apparel

Computer-aided design (CAD) enables designers to draw and modify garment designs directly on a computer, eliminating the need to redraw the entire garment for every change and thereby improving design efficiency while reducing labor and time costs.⁵ Adobe Illustrator can be used at the two-dimensional apparel design stage to create fashion flats, garment details, motifs, and color variations. Technical fashion flats and tech packs represent approved design and construction information in a visually accessible format, facilitating efficient information exchange between the designer and production

team before sampling. This makes it possible to compare multiple design options for the same garment, including the traditional Panjabi, before sample development.¹¹

3D virtual prototyping and CLO 3D

Virtual prototyping involves simulating garment patterns in two dimensions on a three-dimensional body model, providing opportunities to examine fit, silhouette, fabric drape, and construction before obtaining a physical sample.¹² Through virtual simulation, fabric characteristics and garment shapes can be evaluated, thereby reducing the need for multiple physical samples.¹³ Virtual simulation technology can shorten sample development time by about sixty percent, reduce the number of physical samples by more than two-thirds, and save more than two-thirds of fabric costs.¹¹ Three-dimensional virtual fitting allows garment patterns to be draped and evaluated on virtual avatars, enabling multiple design iterations and fit tests without producing physical samples and thereby reducing the number of prototypes required. CLO 3D, among the available tools, provides a widely used environment for virtual draping and fit testing on avatars before production.¹⁴

Integration of 2D and 3D workflows

The combination of 2D vector graphics and 3D virtual prototyping forms an integrated digital workflow in which a garment can be designed, refined, and evaluated before production. Studies on digital prototyping in the fashion sector indicate that integrating digital prototypes into product development can reduce lead times for design, prototyping, and manufacturing. Compared with conventional pattern-making practices, 3D technology has been found to offer time, financial, and resource savings while increasing design flexibility.⁶

Digital technology for traditional garments

The Panjabi, commonly known as a kurta, is a traditional long shirt worn by men in South Asia and is preserved as part of festive and religious dress in Bangladesh. Recent research has used three-dimensional virtual technology to digitize traditional costumes from different cultures. For example, researchers have virtually reconstructed traditional opera costumes in three dimensions, showing that digitizing and simulating traditional costumes can contribute to preserving and propagating costume culture.¹⁵ Similarly, researchers have reconstructed traditional Mazu clothing through pattern making combined with 3D garment simulation to generate virtual representations of cultural clothing and support cultural heritage preservation. Three-dimensional virtual simulation can likewise be used to recreate and communicate cultural clothing designs while maintaining the authenticity of traditional attire. Recent research has demonstrated that digital technologies can support the restoration, reconstruction, visualization, and preservation of heritage clothing through digital and three-dimensional methods.¹⁶

Virtual technology for Bangladeshi garments

The growth of digital technologies has disrupted conventional approaches to the design of ethnic wear. One recent study introduced the BD-VITON virtual try-on dataset for Bangladeshi clothing, including saree, Panjabi, and salwar kameez, with these garments presenting structural challenges related to draping, asymmetry, and deformation.

Fashion education and industry adoption

The growing use of three-dimensional design tools has also affected fashion education. Incorporating two-dimensional and three-

dimensional CAD pattern making into fashion design education improves students' understanding of 3D visualization and encourages critical thinking about the design process, thereby better preparing students for the modern apparel industry.¹⁷

In the apparel industry, comparative studies of three-dimensional virtual and traditional pattern making suggest that adopting three-dimensional technology can encourage professionals to shift toward digital design development because of its time and cost benefits.¹⁸ These trends are important for Bangladesh because the apparel industry is a key sector of the economy and the Panjabi remains a widely worn traditional garment in the country. The sector may therefore benefit from adopting digital tools for both educational and industrial purposes.¹⁹

Yarn, weaving, and fabric material characterization

Textile material characterization for apparel development should distinguish yarn-level, fabric-level, and simulation-level parameters. Relevant yarn descriptors include filament number, yarn type, yarn linear density expressed in tex or dtex, and spinning or texturing technologies such as bi-component yarn (BCY), air-jet textured yarn (ATY), and draw-textured yarn (DTY). Yarn mechanical properties, including tensile strength and elastic modulus, can also influence the resulting textile behavior. Recent reviews of BCY and ATY emphasize the role of yarn structure, filament count, yarn count, processing conditions, and mechanical behavior in determining textile performance.^{20,21} A broader review of textile material properties likewise highlights the importance of documenting physical and mechanical characteristics when textile behavior is interpreted.²² At fabric level, the construction type, such as plain, twill, or sateen, together with warp and weft density, areal density, and thickness, should be documented when available. For a three-dimensional textile structure, any binder-yarn or other structural-yarn information should also be reported when such yarns are part of the construction. In the present case study, the available CLO 3D material record provides fabric-level information but does not provide the requested yarn-level or detailed weave-density measurements; therefore, those parameters are not inferred.

Methodology

Research design

A case study research design was adopted to demonstrate and evaluate an integrated digital workflow for apparel product development using the traditional Bangladeshi men's Panjabi as the test subject. Adobe Illustrator was used to develop the 2D vector-based design, while CLO 3D was used for 3D virtual prototyping and simulation. The study was guided by three research questions concerning 2D design development, 3D garment prototyping and fitting, and the integrated workflow.

Tools and software

Two software tools were used in the research. Adobe Illustrator CC was used as a 2D tool for designing the fashion flat, garment details, motifs, and color variations of the selected outfit. CLO 3D was used to create the virtual prototype, simulate the garment on the virtual model, assign the selected fabric material, and evaluate its visual presentation and fit.

2D design development in Adobe Illustrator

The 2D design of the Panjabi was created in Adobe Illustrator. First, the traditional garment was studied to identify its principal design and construction elements, including the front opening, side slits, collar, and sleeves. The necessary design information was then used to draw the Panjabi fashion flats, with particular attention to garment proportions and construction details. Multiple design variations were explored, including variations in collars, plackets, motifs, and color schemes. The use of vector graphics allowed design elements to be transformed quickly and conveniently without loss of quality. Moreover, the design changes were maintained in a single working file, facilitating the transition from 2D design development to 3D modeling.

Figure 1 illustrates the range of design alternatives explored during the 2D development stage, including variations in collar and placket configuration, motif placement, embellishment, and color combination. These alternatives represent the exploratory design stage from which the final Panjabi design was selected for 3D development.



Figure 1 Design developments and alternatives.

Figure 2 and Figure 3 present the selected Illustrator design together with its supporting motif elements and garment views, which served as the visual basis for subsequent virtual prototyping in CLO 3D.

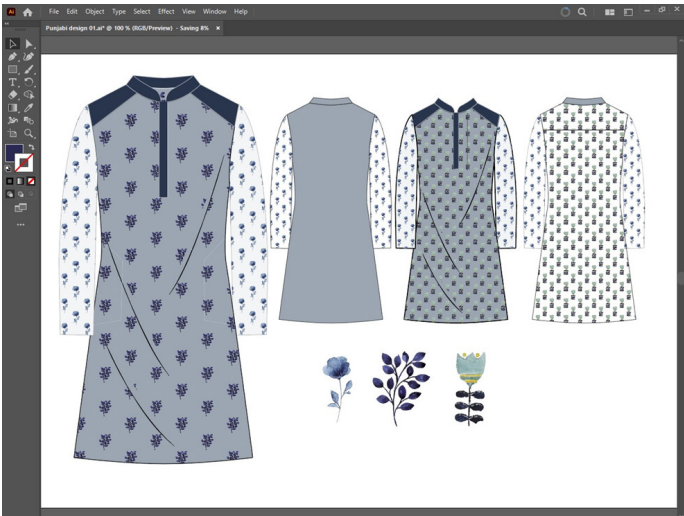


Figure 2 Selected design and motif development.

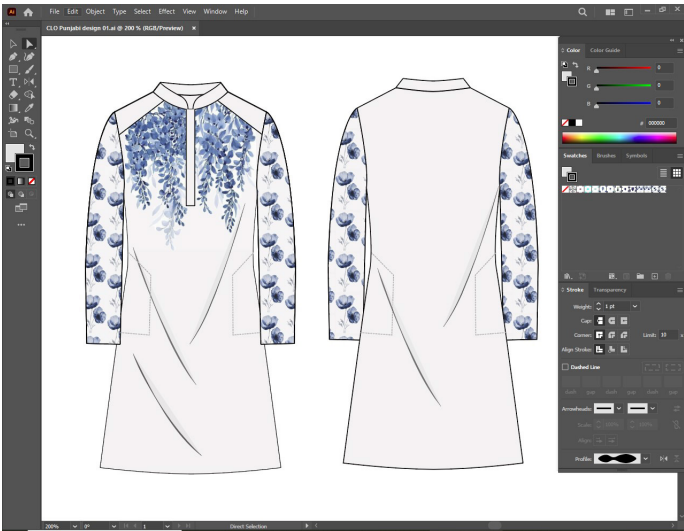


Figure 3 Final design development and motif graphic application.

Yarn and fabric technical information

The technical information available for the material used in the CLO 3D simulation was recorded directly from the supplied material specification. The CLO 3D material file is identified as Silk_Charmeuse.zfab. The interface reports the construction as Woven and the composition as 100% Silk, with a weight of 49.4949 g/m² and a thickness of 0.23 mm. Figure 4 documents the material panel used in the simulation, and Table 1 summarizes the available parameters and explicitly identifies yarn- and construction-level variables that were not supplied. This distinction is important because unavailable yarn or fabric parameters should not be reconstructed from the software screenshot.

Table 1 CLO 3D Virtual fabric parameters

Parameter	Documented value / status
CLO 3D material file	Silk_Charmeuse.zfab
Construction	Woven
Composition	100% Silk
Weight/Areal density	49.4949 g/m ²
Thickness	0.23 mm
Texture	Silk_Charmeuse (CLO 3D material texture)
Yarn-level parameters	Yarn type, filament number, yarn count (tex/dtex), BCY/ATY/DTY technology, elastic modulus (E), and tensile strength: not specified.
Fabric-construction parameters	Specific plain/twill/sateen construction, warp/weft density, and binder-yarn information: not specified.

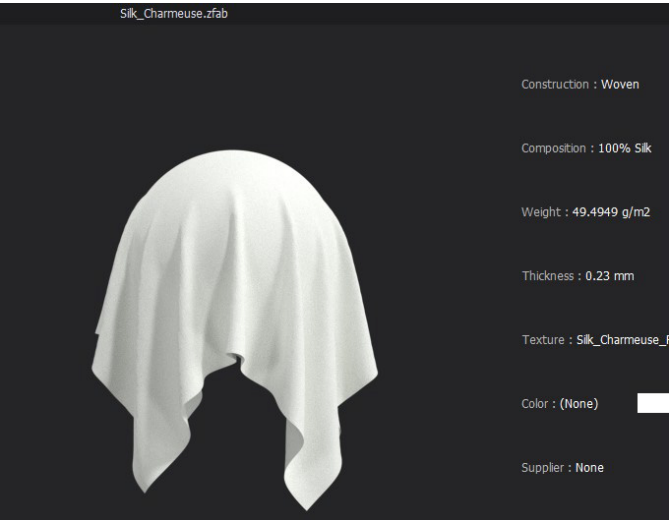


Figure 4 CLO 3D material specification used for the virtual simulation of the Panjabi.

Figure 4 shows the CLO 3D material specification panel used to define the fabric for the virtual Panjabi prototype.

3D virtual prototyping in CLO 3D

The 3D virtual prototype was developed in CLO 3D. First, a virtual avatar was created using the body measurements of the target wearer. The selected 2D garment design was used as the visual basis for developing the corresponding pattern pieces in CLO 3D. The pattern pieces were arranged around the avatar and virtually sewn to construct the garment. The selected material file, Silk_Charmeuse.zfab, was assigned to the garment. The CLO 3D material panel identifies the material as Woven and 100% Silk, with a weight of 49.4949 g/m² and a thickness of 0.23 mm. These documented material inputs were used in the virtual draping and simulation process. The garment appearance, construction details, color combination, material appearance, and fit were then evaluated. Adjustments identified during the virtual fitting process were incorporated into the digital design and re-simulated until the desired outcome was achieved.

Figure 5 shows the CLO 3D working environment during virtual garment construction, where the pattern pieces are positioned around the avatar and prepared for virtual sewing and simulation.

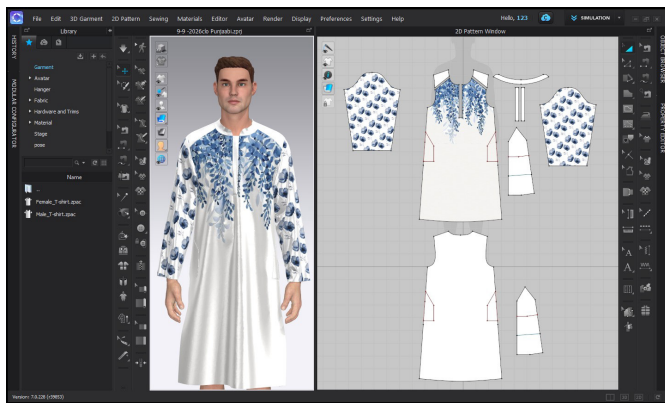


Figure 5 CLO 3D working environment.

Figure 6 provides a closer view of the CLO 3D 2D Pattern Window and the individual garment components used for virtual assembly, illustrating the relationship between the pattern pieces and the resulting garment.



Figure 6 CLO 3D pattern window.

Evaluation of the integrated 2D-3D workflow

The effectiveness of the integrated 2D-3D workflow was evaluated qualitatively in terms of its ability to support design decision-making and preliminary garment evaluation before physical sample production. The evaluation focused on whether the workflow enabled design modification, visualization of alternatives, virtual garment assembly, and identification of potential design or fit-related issues during the digital development stage. Rather than quantitatively measuring reductions in physical sampling, the evaluation considered the extent to which design modifications and preliminary fit-related adjustments could be explored virtually before physical sampling. The workflow was therefore assessed using four qualitative criteria:

- 1) Ease of design modification
- 2) Visualization and comparison of design alternatives

- 3) Ability to identify and address potential garment construction or fit-related issues virtually
- 4) Usefulness of the virtual prototype for final design communication.

The complete digital development process is summarized in Figure 7, which illustrates the sequential integration of 2D vector design, pattern development, 3D virtual assembly, simulation, virtual evaluation, and design refinement.



Figure 7 Integrated 2D–3D digital workflow used for the development and virtual prototyping of the Bangladeshi men's Panjabi.

Results and findings

2D design development in Adobe Illustrator

The 2D design of the traditional Bangladeshi men's Panjabi was developed in Adobe Illustrator. Fashion flats of the selected garment were constructed to illustrate the design from both front and back views, including garment proportions, front opening, side slits, collar, and sleeve construction. The representative design variations shown in Figure 1 demonstrate the exploration of alternative visual treatments, while Figure 2 shows the selected 2D design and supporting motif elements used as the basis for subsequent virtual prototyping. The vector-based approach allowed design variations to be created and modified efficiently.

Eight representative design alternatives were explored during the 2D development stage. These alternatives varied primarily in collar configuration, placket treatment, motif placement, embellishment, and color combination. The final design was selected based on visual coherence, compatibility with the characteristic Panjabi silhouette, and suitability for subsequent 3D implementation, as illustrated in Figure 1. The selected design in Figure 2 demonstrates how the final 2D garment views and individual motif elements were organized before transfer to the 3D environment. The design was developed as 2D vector graphics so that modifications could be made without repeatedly redrawing the garment. This capability provided a practical foundation for the subsequent 3D prototyping stage.

Fabric parameters used in the CLO 3D simulation

The final virtual prototype used the documented CLO 3D material specification shown in Figure 4. The material was classified as Woven and 100% Silk, with a weight of 49.4949 g/m² and a thickness of 0.23 mm. The material file was Silk_Charmeuse.zfab. These values provided the documented fabric-level inputs for the virtual draping and appearance evaluation. The result should be understood as a digital material representation because the present case study did not independently measure the physical fabric in a laboratory.

3D virtual prototyping in CLO 3D

The 2D pattern was converted into a 3D virtual sample using CLO 3D. The pattern pieces were imported into the software, arranged around the virtual avatar, and virtually sewn to construct the Panjabi. The documented fabric properties were assigned to the virtual sample to reproduce the intended material appearance and drape. The virtual sample was then used to evaluate the garment silhouette, construction details, color combination, fabric appearance, and overall fit before physical sample production.

The virtual fitting process enabled assessment of garment fit and silhouette on the virtual body, consistent with the role of virtual prototyping in evaluating garments before production. Changes identified during virtual fitting were implemented digitally and the garment was re-simulated until the desired specification was achieved.

Figure 8 summarizes the resulting virtual prototype through front, back, and three-quarter rendered views, demonstrating the final appearance of the digitally developed Panjabi on the virtual avatar.



Figure 8 Final rendered prototype.

Evaluation of the integrated 2D–3D workflow

The integrated process enabled the designer to build, explore, and modify the Panjabi design without immediately producing a physical sample. A principal benefit of the workflow was that potential fitting and design issues could be addressed virtually before physical sampling. This finding is consistent with previous research indicating that virtual simulation can accelerate sample development and reduce the number of physical samples required.

Discussion

Interpretation of findings

The findings demonstrate the practical value of combining 2D and 3D digital tools for developing a garment that retains important characteristics of the traditional Panjabi. The design-development sequence illustrated in Figure 1 and Figure 2 shows how alternative visual treatments could be explored in the 2D environment before a selected design was transferred to CLO 3D. Working in Adobe Illustrator allowed the designer to develop and modify design variations during the 2D stage. Visualizing the selected design in CLO 3D then made it possible to examine how the garment would appear and fit on a virtual model. The selected CLO 3D material specification a woven 100% silk material with an areal weight of 49.4949 g/m² and a thickness of 0.23 mm, provided the material basis for the simulated garment appearance and drape (Figure 4). Because these values

came from the digital material specification, rather than independent laboratory testing, the result should be interpreted as a virtual material representation. The workflow allowed design decisions to be made before physical sampling, offering a potential advantage over conventional sampling in terms of development time and resource use. The workflow also demonstrated that digital tools can be applied to traditional garments while retaining their distinctive identity. In the present case, the Panjabi was given a more contemporary visual treatment while maintaining recognizable traditional lines and construction features.

Comparison with previous studies

The findings are consistent with previous research showing that 3D virtual prototyping can support evaluation of garment fit and silhouette before manufacturing and that virtual garments can be developed and assessed on avatars within 3D virtual environments. The present study extends this body of work by applying an integrated 2D–3D workflow to a traditional Bangladeshi garment, an area that has received comparatively limited attention. Earlier work such as the BD-VITON dataset has focused on virtual try-on of Bangladeshi garments, whereas the present study addresses the systematic design and prototyping of a Panjabi. In addition, recent textile reviews emphasize the importance of distinguishing yarn-level descriptors, fabric construction, and mechanical properties when textile behavior is interpreted; relevant descriptors include yarn type, filament number, yarn count in tex or dtex, spinning or texturing technologies such as BCY, ATY, and DTY, tensile strength, and elastic modulus. The present case documents the fabric-level parameters available in the CLO 3D material panel but does not infer missing yarn-level properties.

Implications for fashion education and the apparel industry in Bangladesh

The findings have implications for both fashion education and the apparel industry. In fashion education, 2D and 3D digital technologies could be incorporated into the curriculum to equip students with digital design and virtual prototyping skills relevant to the contemporary apparel industry. For the apparel industry, the workflow offers a means of conducting design development and virtual fitting before physical sampling, with potential benefits for sampling time and resource use. These benefits are particularly relevant to Bangladesh, where the apparel industry is a major manufacturing sector and traditional garments such as the Panjabi remain widely worn.

Limitations

The findings should be interpreted in light of the study's case study design. Only one garment type, the traditional Bangladeshi men's Panjabi, was examined; therefore, the findings cannot be assumed to be generalizable to other garment categories without further investigation. In addition, the workflow was evaluated qualitatively and was not quantitatively compared with conventional apparel development in terms of development time, number of physical samples, material consumption, or cost. Consequently, the study demonstrates the practical feasibility and potential benefits of the integrated digital workflow rather than providing quantitative evidence of efficiency gains. The CLO 3D material information available for this case specifies a woven, 100% silk material with an areal weight of 49.4949 g/m² and a thickness of 0.23 mm, but the supplied material panel does not provide yarn type, filament number, yarn count, spinning or texturing technology, yarn elastic modulus, yarn tensile strength, specific weave construction such as plain, twill, or sateen, warp/weft density, or binder-yarn information. These missing yarn-

and fabric-construction parameters were therefore not estimated or introduced as assumptions. Because no physical prototype or wearer trial was conducted, the virtual fit assessment should be interpreted as a digital evaluation of garment–avatar interaction rather than empirical validation of physical garment fit. Similarly, simulated fabric behavior depends on the accuracy of the assigned material parameters and the characteristics of the digital avatar. The static virtual evaluation also does not fully represent dynamic garment behavior during body movement or the tactile and constructional characteristics that can only be assessed through physical sampling.

Future research

Future studies should examine a broader range of traditional and contemporary garments and incorporate quantitative comparisons of development time, physical sample requirements, material consumption, and cost. Physical prototype testing, wearer evaluation, and dynamic 3D simulation could also be used to further validate the findings and establish the practical effectiveness of integrated 2D–3D digital product development.²³

Conclusion

This study investigated the application of an integrated 2D–3D digital process to apparel product development using a traditional Bangladeshi men's Panjabi as a case study. Adobe Illustrator was used to develop the garment in 2D, including fashion flats, design variations, and decorative motifs, while CLO 3D was used for pattern development, virtual prototyping, visualization, simulation, and virtual fit assessment. The documented CLO 3D material specification was a woven, 100% silk material with an areal weight of 49.4949 g/m² and a thickness of 0.23 mm. The results demonstrate that the integrated digital workflow can support garment design, visualization of design modifications, and preliminary evaluation of silhouette, simulated fabric appearance, construction, and garment–avatar interaction before physical sample production.

The study addressed its research objectives through the development of the 2D Panjabi design, the creation and evaluation of a CLO 3D virtual prototype, and the qualitative assessment of the integrated 2D–3D workflow. The findings demonstrate that Adobe Illustrator can support the development and modification of Panjabi fashion flats and design variations, while CLO 3D can support pattern assembly, virtual sewing, material assignment, simulated draping, and visual assessment of garment silhouette and virtual fit. Taken together, the workflow provides a systematic means of conducting design refinement and preliminary virtual evaluation before physical sampling. This creates an opportunity to identify and address selected design and fit-related issues digitally before committing to physical prototypes.

The case further indicates that design modifications, motif adjustments, and preliminary fit-related refinements can be explored within the digital environment before physical sampling. However, the magnitude of any reduction in physical sampling, development time, material consumption, or cost cannot be established from the present case study. These outcomes require quantitative comparison with conventional apparel development processes. The integrated 2D–3D process may also have applications in the development of other traditional and contemporary garments and could be adopted as a digital design and prototyping approach in apparel education and industry settings, including Bangladesh's apparel sector.

Future research should quantitatively evaluate the integrated workflow through comparative studies measuring development time, physical sample requirements, material consumption, and cost.

Further validation through physical prototypes, wearer trials, and dynamic garment simulation would also strengthen understanding of the relationship between virtual evaluation and physical garment performance.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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