Article

Assessing Students' Aptitude in Analysing 3D Scanned Women's Body Shapes to Improve Fashion Curriculum Design

Reena Pandarum
https://orcid.org/0000-0001-6964-8823
University of South Africa
pandak@unisa.ac.za

Abstract

Unisa emphasises responsive student-centredness, recognising the role of an engaged student for future career success and lifelong learning. This research adopted a learner-centred approach, integrating point cloud scans from a 3D full-body scanner into a module for third-year fashion and textile undergraduates. Traditionally, the fashion sector designs apparel for an hourglass woman's body type. However, South African researchers report that this shape does not represent the majority of women in the country. This research aimed to assess the competence of undergraduate fashion students in visually assessing women's body shapes to develop cognitive skills for the workplace. Twenty-nine students visually assessed 31 3D scans provided as 2D black and white images. The experts and students identified the dominant shapes of spoon, hourglass and rectangle. In addition, the students reported the triangle, inverted triangle and diamond. Of the 31-point cloud images, 52% of the student's classifications correlated with those of the clothing industry experts; 48% of the students experienced challenges in accurately assessing asymmetrical body shapes with varying frame sizes across different classifications. The findings suggest that fashion students demonstrate a degree of skill in visually assessing women's body shapes. Recommendations include using 3D printed models and interactive 360° videos to enhance cognitive abilities. Integrating 3D scanning technology into the curriculum offers sustainable benefits by streamlining processes, improving digital competence and standardising body measurements to SANS 8559-1. This integration not only develops essential workplace skills but also educates students on minimising waste throughout the design-to-garment construction process, thereby aligning academic instruction with industry norms.

Keywords: 3D body scan; South African women; fashion curriculum design; technology-enhanced teaching; ODeL; visual assessments

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Introduction

Various criteria are used in the development of product standards and specifications in the fashion sector (Kadolph 2008, 333–7). Extracting body measurements for garment manufacturing, sizing and fit is one such criterion. The body measurement data can be collected using either a dressmaker's tape measure, callipers and 3D body scanner or live fit models to develop size charts. The garment sizes are coded numerically or alphabetically, as seen on the retail-bought garment size labels. However, garment size charts are propriety to the fashion retailer or manufacturer and are target market driven (Phasha et al. 2020). Although attempts have been made to relate body shapes to linear body measurements, the derivations of algorithms or rules used to define the measurements for different morphotype categories are not in the public domain (Lee et al. 2007; Milliam 2021; Simmons et al. 2004).

Research suggests that the same style garment in different retail stores or even within the same retail brand are not consistent in size and fit and are attributed to differently shaped bodies (Connell et al. 2006; Lee et al. 2007; Liechty et al. 2010; Milliam 2023; Muthambi et al. 2015; Phasha et al. 2020, Simmons et al. 2004; Strydom 2006; Zwane and Magagula 2006). The starting point of developing any size chart is to extract accurate anthropometric measurements and to assess the body shape or morphotype category to determine the drape and fit of a garment on the body (Pandarum et al. 2021). Furthermore, Makhanya and Mabuza (2020) emphasise the importance for fashion manufacturers to understand the relationship between body shapes, body satisfaction and fitting preferences to adapt their marketing strategies to improve the fit of target markets. Manufacturers therefore need to acknowledge the diverse body shapes and incorporate cultural and ethnic variations when developing size guides and designing garments.

Currently, students who study fashion are expected to acquire skills on how to extract the key human body points of measure to develop basic pattern blocks in their first-year fashion practical using tape measures that are prone to measurement errors and are very intrusive. This is especially true in plus-sized women where the tape measure sinks into the skin, making it challenging to locate the exact body point of measure.

Learner-Centred Approach to Learning

Numerous studies have explored the integration of student-centred learning and technology in classrooms, and drive ongoing changes in the education curricula (Bremner et al. 2022; Keengwe et al. 2009) where the focus is on the student rather than the teacher. The teacher facilitates the learning with the students collectively to find corrective measures to improve the learning process. Establishing an optimal learning environment is crucial, and educators must understand knowledge-building processes to integrate them appropriately into the module and curriculum. Assessment methods should promote learning, and incorporate self- and peer-evaluation strategies. When the elements of learner-centred teaching are effectively balanced, learners can retain knowledge and develop skills for lifelong learning (Weimer 2002).

Literature Review

Advantages of 3D Full-Body Scanning Technology

The emergence of 3D scanning technology in South Africa, and the affordability of this electronic tape (e-tape), body volume and point cloud measuring equipment offer alternative approaches to assessing anthropometric sizes and/or classifying the body in 3D in rotational views. 3D scanning also enables the development of novel protocols for apparel sizing and fit that collect anthropometric data quickly and non-intrusively in large quantities in a short time. A study conducted by Levi (Elbrecht and Palm 2016, 1) found that measurements from 3D full-body scanners are “76% more accurate than that of the most skilled hand-measuring expert”. Extracting body measurements from full-body scanners such as the [TC]2 NX-16 is far superior as the software interface is user-defined. These instruments negate the compression caused by callipers and dressmakers’ tape measures when body measurements are extracted manually. Furthermore, Simmons (2003) mentioned that the [TC]2 (2016) scanners were developed for the fashion industry, where the body landmarks are programmed automatically. The body points of measure or landmarks can be correlated with international or national standards without the fashion designer/researcher having any physical contact with the subject.

Figure Typing in the 20th Century

The 20th century also saw emphasis placed on the concept of a perceived ideal figure type. The body proportions and fashion ideal figure forms seen today on the African continent reflect the Western-styled apparel worn in everyday life by people of African or southern African descent. This is driven largely by the adoption of Western societal norms. The lack of a uniquely South African or African sizing system, the unavailability of cultural fashion in retail stores, and the “global village” concept of “free trade” with worldwide fashion imports are all contributing factors to this (Pandarum et al. 2011). Such trends pose a challenge for the local and global garment manufacturing industries as retailers and garment manufacturers still design predominantly for the hourglass figure type, using anthropometric data measurements from the 1940s (Gribbin 2014).

The same holds true for South Africa as the garment manufacturing and retail industry, cannot lay claim to a uniquely South African garment sizing system (Milliam 2024). Liechty et al. (2010) mention that, when evaluating the body, one needs to consider subtle characteristics such as the symmetry or asymmetry of the body as one’s body is not balanced from side to side. This is explained as an individual having a narrow shoulder and a narrow back or a small midriff and waist with a prominent bust, or the inverted triangular figure type with thin legs and flat buttocks. These complex combined figure variations are therefore what we ultimately recognise as “typical postures” such as sway back or slumped posture or figure types such as the inverted triangle or the spoon. All these body and figure variations ultimately influence the fit or misfit of a garment, as manufacturers and retailers do not cater for body variations (Pandarum et al. 2021).

Body Shape/Morphotype Analysis Theory/Rules

In body morphotyping, the torso is considered the primary indicator of the body's shape for adult women (Xu et al. 2003). Stefan and Gilbert (2016, 304) concur that the shape of the body torso is an excellent indicator of the overall shape of a woman. The authors further cite that the torso length remains constant over the lifespan of an adult individual and, therefore, is a fixed length in adult women. Associated with body morphotypes are descriptors such as hourglass, triangular, pear or spoon, rectangular and diamond used to explain a particular body type in the fashion sector. However, advances in technology dictate that students gain new knowledge in the digital environment that is quick, non-intrusive and sustainable as the measurements can be repeated that minimise fabric waste generated in the classroom. Integrating digital technology such as a 3D full-body scanner in the fashion teaching and learning curriculum where the landmark extraction process is aligned with the SANS 8559-1 (2019) standard has the advantage of precision sizing; hence, minimising alterations made to pattern blocks owing to the incorrect fit and size on differently shaped women bodies. With accurate measurements from a 3D scanner, garments can be customised in made-to-measure or bespoke fashion, where each item is tailored to fit an individual's unique body shape and size. Furthermore, the 3D data can optimise the pattern-making process by extracting large amounts of body measurement data to develop software to analyse body shapes and sizes of target markets or an individual thereby minimise waste by creating more efficient and accurate patterns blocks of different sizes for differently shaped women.

Morphotype Theory

According to Brannon (2000, as quoted in Connell et al. 2006), the rating scale was provided to the rater in her body scanner study towards developing the BSAS© software tool; however, this body morphotype 3D continuum theory was taken from a study of body shapes and postures for men and not for women (figure 1). Ruto (2009), in his study on dynamic human modelling and animation, mentions that the torso shape can vary in different aspects, namely, variations in the torso, height and posture (see figure 2). These variations are important when analysing the shape of the body. This anomaly is negated when using 3D scanning technology as the subject's scanning position is dictated and standardised by the scanner manufacturer.

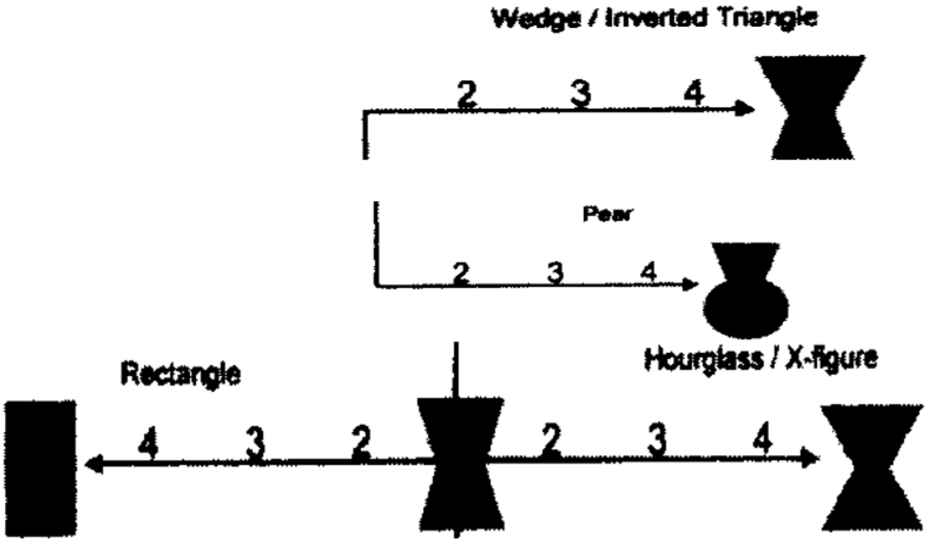

Figure 2: Body shape continuum scale (adapted from Brannon (2000, as quoted in Connell et al. 2006)

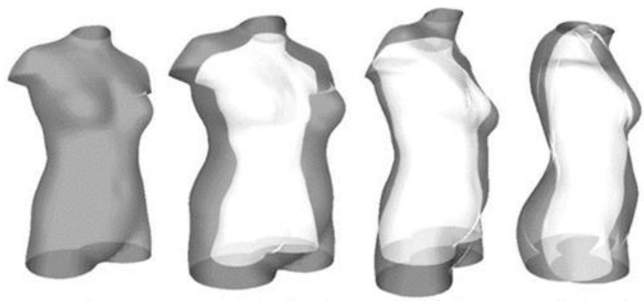

Figure 1: Examples of the different variations that occur in the shape of the torso (Ruto 2009)

Research Methodology

The New Normative Method Body Diagram

The algorithms for the different women's body shapes were developed as the new normative method (NNM) (Pandarum et al. 2021). This study determined the limits of nine body silhouettes according to the ratios of bust, waist and hip girth measurements that were presented to the 29 students with the body shape diagram as shown in figure 3. From the subjective assessment of a sample of 3D scanned body surfaces and the objectively measured body dimensions, statistical analysis was used to derive limits for the bust to waist, and hips-to-waist girth ratios to distinguish between and, hence, predict the different point cloud body outlines. The method was developed using a convenience sample of 341 South African women ranging from 18-65 years who were scanned using a [TC]2 NX-16 structured white light, full-body scanner to derive their body measurements. Body point cloud outlines were assessed by analysing the front, side and back views of the 3D body point cloud outlines, focusing on the primary body dimensions as represented in figure 3. The sampling was conducted without replacement. The geographical and anthropometric data for the women were collected under clearance approval H15-SCI-TEX-001 and the generic ethical clearance number 2011/CAES/044 of the University of South Africa. The instruction provided in the project assessment stated "Choose only one body morphotype category from the diagram provided that was extracted in point cloud. The hourglass figure type indicates the position of the bust/waist/hip girths on the morphotype diagram".

Tick (√) your choice on the body morphotype diagram.

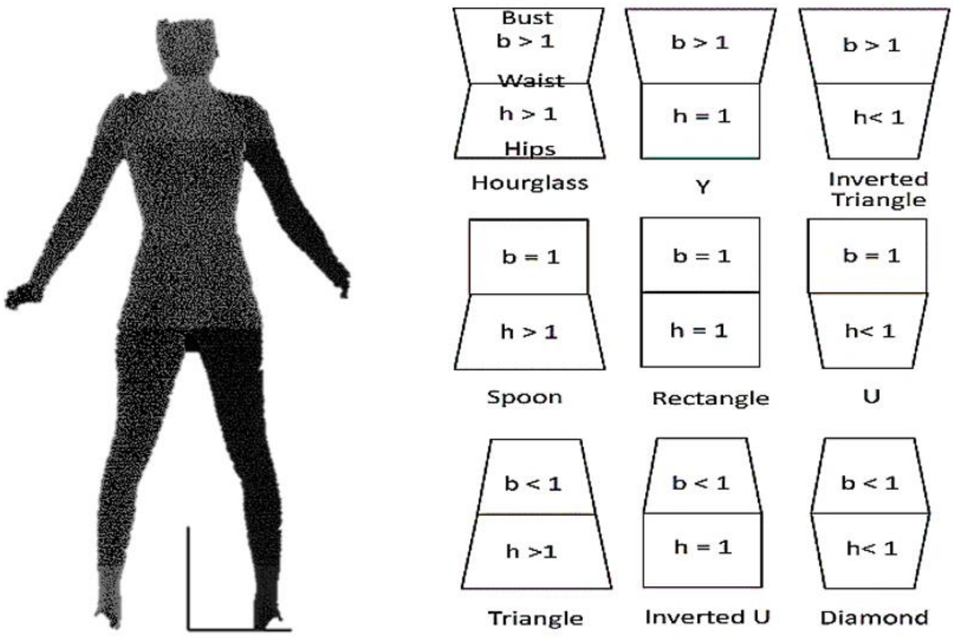

Figure 3: Author silhouette: 2D image and body shape diagram developed by Pandarum et al. (2021)

Learning Objective

Twenty-nine undergraduate students in the Fashion Retail and Fashion Small Business Management streams visually assessed a total of 31 3D scans presented as 2D black and white body point cloud outlines totalling 899 scans. Their ages ranged from 18 to 40 years, they were from “all walks of life” and 99.5% were female and 0.5% male students.

This longitudinal study conducted from 2020 to 2023 presented to third-year students in the “Evaluation of Apparel” module as a project was assessed with a rubric. Thirty-one 3D scanned outlines of body shapes/morphotypes of women were extracted in 3D point cloud. Students were tasked to view the torso outlines of the body in 2D to visually assess each body shape to write a report of no more than 2 000 words under the headings provided. The completed appendix and the consent forms were attached to the final project submission.

Results and Discussion

Among the 31 scanned body point cloud images, 52% of the student’s shape classifications correlated with those of the clothing industry experts as presented in Tables 1 and 2. The experts identified the dominant shapes of spoon (68%), hourglass (16%) and rectangle (13%). In contrast, the students assessed the spoon (48%), hourglass (23%) and rectangle (16%). However, the students additionally reported the triangle (7%), inverted triangle (3%), and diamond (3%) body shapes indicating that the students encountered challenges in evaluating asymmetrical shapes of varying body sizes (refer to figure 4) within and across the different classifications. Mabotja and Nganase (2024) attributes this to students residing in urban and rural areas that may have different perceptions on body images, where their traditional cultural values may conflict with Western beauty standards.

Table 1: Expert assessed according to the new normative method

Expert assessed according to the NNM				
Body shape	**Frequency**	**Percentage**	**Valid percentage**	**Cumulative percentage**
hourglass	5	16.1	16.1	16.1
rectangle	5	16.1	16.1	32.3
spoon	21	67.7	67.7	100.0
Total	31	100.0	100.0	

Table 2: Dominant shape assessed by students

Dominant shape assessed by students				
Body shape	**Frequency**	**Percentage**	**Valid percentage**	**Cumulative percentage**
diamond	1	3.2	3.2	3.2
hourglass	7	22.6	22.6	25.8
inverted	1	3.2	3.2	29.0
rectangle	5	16.1	16.1	45.2
spoon	15	48.4	48.4	93.5
triangle	2	6.5	6.5	100.0
Total	31	100.0	100.0	

Owing to the limited number of male students enrolled in the module, the author was unable to determine whether there were significant differences in the approaches to visually assessing body shapes between male and female students. In response to the following statement and question “Explain how easy or difficult it was to identify the different morphotypes. Which was the most difficult to identify visually and which was the easiest to identify visually and why?” some students stated:

> The researcher also found that the easiest body shape to determine is the hourglass body shape and the most difficult is the inverted triangle and Y. The researcher had difficulty to identify certain body shapes as some body shapes look similar to one another. This shows the importance of body shapes for both retail stores and women as retail stores will make clothes that suit all body types and how women's body shape knowledge allows them to better fashion choices to suit their body shape.
>
> Overall, the exercise of identifying the different morphotypes was relatively easy, thanks to the clear images and diagrams provided in appendix A. The hourglass body shape was the easiest to identify visually because of its distinctive waist-to-hip ratio, while the Y, inverted U, diamond, and U body shapes were more difficult to identify due to their similar waist-to-hip ratio.

Figure 4: Author image: An example of an asymmetrical body shape

Conclusion

The findings indicate that third-year fashion students possess the ability to visually assess women’s body shapes when guided through the process. However, some students encountered difficulty assessing asymmetrical shapes of varying body sizes within and between the nine body-shape classifications. Most students identified the hourglass as the easiest to recognise saying "Hourglass body shape was the easiest to identify visually because of its distinctive waist-to-hip ratio" and that the inverted U, diamond, and Y shapes were the most difficult to assess. This project assessment can be redesigned to consider the above comments.

There is also a need to introduce and acquaint fashion students with more digital content in the fashion retail and small business management streams. Exposure to 3D digital technology will better acquaint students with conceptualising and conveying ideas in 3D such as in CAD designing, and incorporating 3D virtual marketing and retail solutions that will be invaluable workplace integration tools. This is particularly relevant for today's technology-driven apparel industries seeking to engage modern consumers who are technologically adept and invested in product innovation and fashion style trends.

Recommendations

The recommendations are to provide supplementary assistance using 3D printed models in interactive 360^{o} views as a video to enhance student cognitive skills. Integrating 3D full-body scanning technology into the curriculum offers sustainability benefits by saving time, enhancing digital proficiency, and standardising reliable body measurement extraction protocols to SANS 8559-1. This practice will minimise fabric waste from design to manufacture and align classroom practices with workplace norms addressing SDG-12.

Incorporating 3D body-scanning and shape anthropometric assessment expertise into the fashion curriculum is advantageous for advancing 3D CAD design and technological innovation.

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