Systematic Approach for a Modular Garment Design

Boowon Kim and Elizabeth Bye, University of Minnesota

Keywords: Modular design, laser-cutting, conceptual, sequencing order

Introduction

A modular garment is a clothing item created with interchangeable modules, which are components that build a larger structure or product (Baldwin & Clark, 2000; Chen & Lapolla, 2021). Modular garments include component and geometric types of design. A component modular garment has garment parts as a module (e.g., sleeve, collar), while a geometric modular garment has a geometric-shaped module (e.g., square, puzzle piece) (Li et al., 2018). Both provide design transformation by simply changing the module rather than requiring the whole garment to change, extending the garment's lifetime (Zhang et al., 2024). A geometric modular garment is comprised of repeated modules to assemble a complete system (Gershenson et al., 2003; Li et al., 2018).

There is no one correct answer to determine the system of modularity, and designers can freely decide the arrangement depending on the design needs. However, using a systematic method during the design process contributes to strong design solutions (Bye & Griffin, 2015; Cross, 1989; LaBat & Sokolowski, 1999). A systematic approach to finding design rules associated with a modular garment, such as module arrangement or shape, may encourage the replication of modular designs. Zhang et al. (2024) also suggest identifying design rules associated with modularity and design interfaces to promote modular fashion practice. A systematic approach, especially regarding module arrangement is lacking; thus, the purpose of this design is to identify a systematic approach to arrange modules in order to create a complete garment. The following question informed the design process: How can a sequence be developed that supports an arrangement for a modular garment?

Aesthetic Properties and Visual Impact

Modular designs involve the collective organization of repeated modules to create the entire system, a garment (Salvador, 2007). A jigsaw puzzle piece with two tabs and two blanks was selected for the module (see Figure 1). The modules were cut into a single size (width: 5 in., length: 5 in.) and connected to one another at the side. Connected modules were formed into to a group, and the number of modules connected in each group followed the formula: $f(n) = 2^{n-1} + 1$ $(n = 1, 2, 3, 4, 5)$. The n represents a group number. The first group had two modules attached, followed by the groups of three, five, nine, and 17 modules (see Figure 2). Then, the groups were repeated in reverse order (i.e., 9, 5, and 3). Each module group was joined by interconnecting and folding the module pieces together (see Figure 2). The last group was then wrapped around to connect with the first group, thus enabling a sequence of flat modules to form a three-dimensional shape that surrounds the body.

Regarding the garments' surface pattern, multiple jigsaw puzzle shapes were printed as the module shape. The vector images of puzzle pieces were first created in Adobe Illustrator (AI) and layered with different colors (see Figure 3). Vivid colors (e.g., yellow, purple, and red) were chosen to provide a visual contrast distinct from the main fabric. Lastly, the printed and non-printed modules were connected next to each other to accentuate the contrast.

Methods: Process, Technique and Execution

The design process included module selection, sequence pattern identification, and prototype development. Puzzle shapes were selected for module development as jigsaw puzzles encompass playful activities and creative construction. Both muslin and paper were laser-cut into multiple puzzle shapes and sizes, and the materials were freely experimented with to seek modularity. A single jigsaw puzzle shape was versatile because it shared the same length on each side, making it easier to attach and detach modules in any configuration. The shape was further experimented with by connecting and rearranging the pieces, until a workable sequence was found by observing the number of modules used. The module numbers used in the first three groups were counted, and the difference between each group was repeated in a sequential order of one, two, and four, which were 2^0, 2^1, and 2^2. Next, groups were determined to continue the sequence, and the formula was developed.

The initial prototype was developed after identifying the sequence. The vector image of the final module was made in AI to laser-cut the muslin. The modules cut were sewn together to make up the groups, and then the groups were joined (2–3–5–9–17–9–5–3). The joined modules were draped on the dress form, and the shoulder straps were developed during the draping. Three modules were vertically connected to create the straps, which completed the initial prototype. The final prototype was constructed after confirming the final module numbers and construction patterns. The procedure involved fabric selection, printing, laser-cutting, and garment assembly. The final prototype used 100% polyester felt. The fabric was first printed using a digital heat transfer machine. Both printed and non-printed plain fabrics were then laser-cut into the module pieces. The modules were arranged and sewn together. Lastly, a set of hooks and eyes was sewn on the tabs at the center of the back.

Cohesion and Design Contribution

Seventy modules were used and connected sequentially to comprise the whole system, a garment. The design contributes to a modular garment practice by presenting a garment with a puzzle module and arranging the modules in a sequence using the formula. It extends the literature by supporting diverse geometric figures in a modular garment and enabling a systematic approach to module design practice. Future studies may also explore the formula with other module shapes and sizes to refine associated rules.

This conceptual piece also provides transformability by rearranging the module groups. Each module group can be added or removed by simply connecting or disconnecting straight seams. Doing so will enable altering the garments' fit and shape, providing versatile use of the garment and extending its lifetime. Although the design offers many possible rearrangements, the limitation includes that the modules were sewn rather than using interlocking methods. Such methods (e.g., zippers, snaps) can be explored in future studies.

Figure 1. *Module Shape*

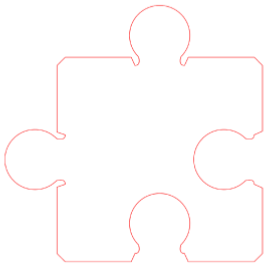


Figure 2. *Module Arrangement*

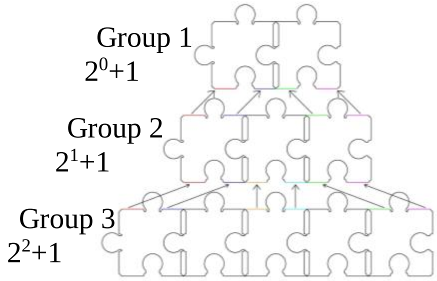
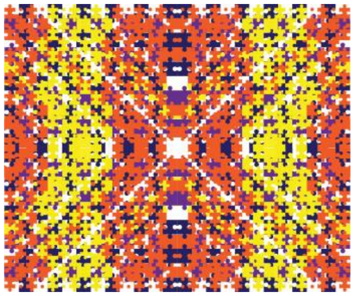


Figure 3. *AI File for Printing*



References

Baldwin, C. Y., & Clark, K. B. (2000). *Design rules: The power of modularity*. The MIT Press. https://doi.org/10.7551/mitpress/2366.001.0001

Bye, E., & Griffin, L. (2015). Testing a model for wearable product materials research. *International Journal of Fashion Design, Technology and Education*, *8*(2), 139–150. https://doi.org/10.1080/17543266.2015.1018959

Chen, C., & Lapolla, K. (2021). The exploration of the modular system in textile and apparel design. *Clothing and Textiles Research Journal*, *39*(1), 39–54. https://doi.org/10.1177/0887302X20937061

Cross, N. (1989). *Engineering design methods*. Wiley.

Gershenson, J. K., Prasad, G. J., & Zhang, Y. (2003). Product modularity: Definitions and benefits. *Journal of Engineering Design*, *14*(3), 295–313. https://doi.org/10.1080/0954482031000091068

LaBat, K. L., & Sokolowski, S. L. (1999). A three-stage design process applied to an industry-University textile product design project. *Clothing and Textiles Research Journal*, *17*(1), 11–20. https://doi.org/10.1177/0887302X9901700102

Li, M.-M., Chen, Y., & Wang, Y. (2018). Modular design in fashion industry. *Journal of Arts and Humanities*, *7*(3), 27–32. https://doi.org/10.18533/journal.v7i3.1271

Salvador, F. (2007). Toward a product system modularity construct: Literature review and reconceptualization. *IEEE Transactions on Engineering Management*, *54*(2), 219–240. https://doi.org/10.1109/TEM.2007.893996

Zhang, X., Le Normand, A., Yan, S., Wood, J., & Henninger, C. E. (2024). What is modular fashion: Towards a common definition. *Resources, Conservation and Recycling*, *204*, 107495. https://doi.org/10.1016/j.resconrec.2024.107495