Parametrix: A Novel Approach to Teaching Parametric Design in K12 and Digital Fabrication Education

Emre Dayangaç[1], Mehmet Bener[1], and Sedat Yalçın[1]

[1] Hisar School IdeaLab Fablab, Istanbul, Turkey

Abstract
Parametric designing is a transformative approach in Computer-Aided Design (CAD) where the geometry adapts dynamically based on user-defined parameters. Despite the valuable propositions of this technique [5], it remains underused due to a lack of resources suited for complete beginners, causing the technique to have a steep learning curve [2]. Recent work has highlighted how parametric design tools, while powerful, tend to be less accessible to beginner designers compared to direct manipulation tools [7]. To address this gap, Parametrix introduces parametric design to K12 students and beginners in digital fabrication through an accessible and structured learning platform. With an intuitive and interactive interface, Parametrix provides a hands-on introduction to the logic of parametric design, allowing users to experiment with and create their own parametric models. Developed in collaboration with teachers, Parametrix is a web platform that teaches parametric design principles in an accessible way. Through an approachable and user-friendly interface, it provides an easy introduction to the logic of parametric designing and is a medium to create various designs parametrically [3]. Parametrix teaches parametric design using an applied method that helps students develop creativity and collaborative competency [4]. Through Parametrix, we aim to foster a more engaging and effective learning environment for those new to digital fabrication and parametric design.

Keywords and Phrases: Parametric Design, Computer Aided Design Education, Digital Fabrication, Web Application

1. Introduction

1.1 Tutorial Interface
Parametrix mainly consists of two sections: the tutorial interface and the playground interface. The tutorial interface serves as the starting point for digital fabrication students to explore and learn the basics of parametric designing. The tutorial interface contains 9 distinct tutorials ranging from a simple cube to a space rocket, providing a framework for creating real-world objects in a parametric fashion. Each design is introduced through a booklet on the website. The booklet contains step-by-step instructions to build the design, but users are encouraged to experiment on their own before following each step. Previous research in digital fabrication education has proven that providing both a textual and graphical interface can significantly reduce the learning curve of digital fabrication techniques [8]. Building on this, Parametrix

Dayangaç, E., Bener, M., & Yalçın, S. (2025). Parametrix: A Novel Approach to Teaching Parametric Design in K12 and Digital Fabrication Education. *Constructionism Conference Proceedings, 8/2025*, 503–506. https://doi.org/10.21240/constr/2025/43.X

uses a split screen layout, where the left side contains the textual section while the right side contains the graphical interface, in the construction environments. In the tutorials, the user creates every geometry by prompting a fine-tuned large language model, flan-t5 in this case, which is designed to deduce the particular shape the user desires to create from the inputted prompt. The large language model was fine-tuned by us on our training data made up of custom prompts. For instance, to create a circle, a student may input: “Create a circle with a radius of 5 on XYConstructionPlane at (0,0,2)”. In the tutorial interface, students interact with the learning environment by learning from the booklets and creating shapes in the construction environments using the large language model. These interactions helps students understand parametric relationships and improve their computational thinking skills.

1.2 Playground Interface

The second interface is the playground interface, where the user can make quick prototypes of any project. By using the prompts for the shapes they learned to create parametrically, they may construct designs for the object they desire. Also, users may work on two or three-dimensional workspaces in Parametrix depending on the needs of their design. Here, users deepen their understanding of parametric design by experimenting with the playground interface.

1.3 Export and Fabrication

Parametrix enables users to bring their parametric designs into the real world through various fabrication options. Users can export their models as STL files for 3D printing or further refinement, making the transition from digital to physical seamless. For those needing additional modifications, DXF exports are also available for use in CAD software or digital fabrication tools such as laser cutters.

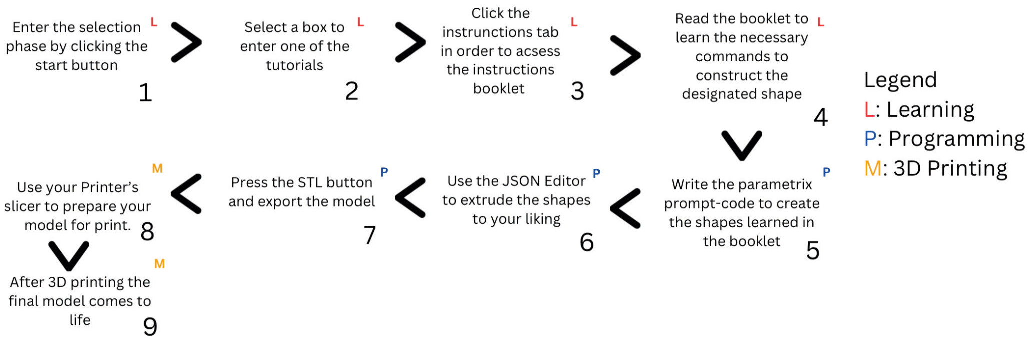

Figure 1: Parametrix Workflow

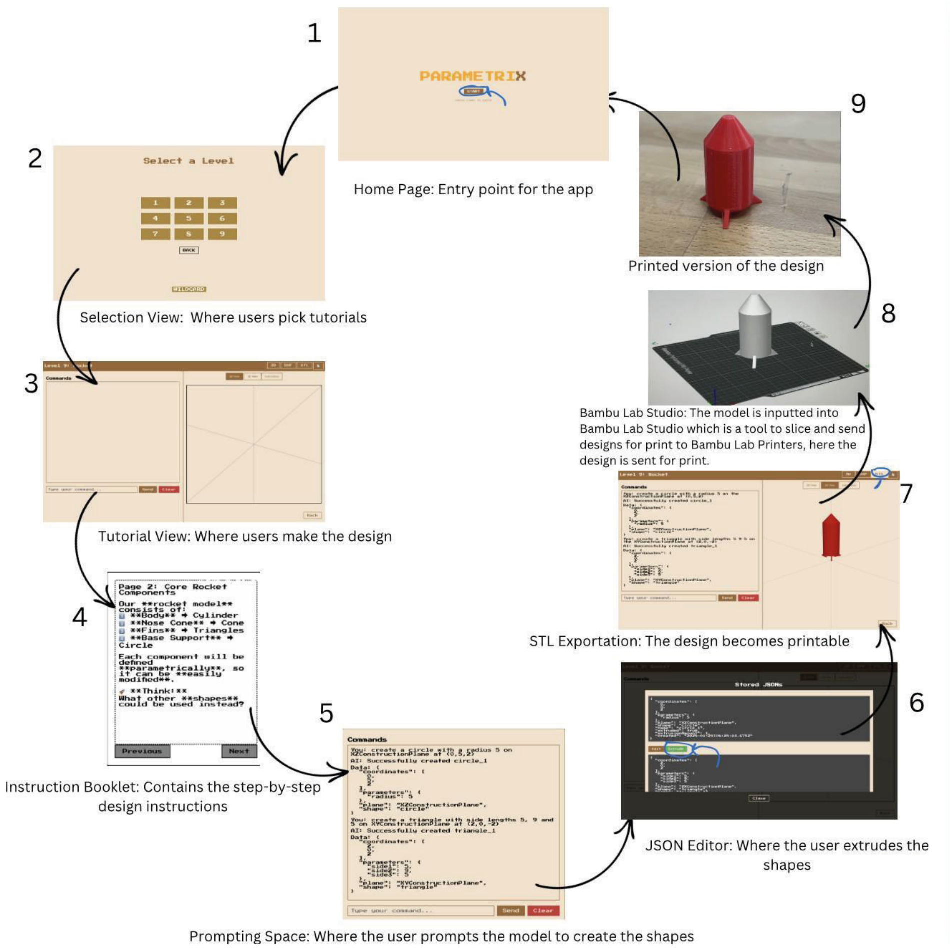

Figure 2: Parametrix Ecosystem.

2. Future Steps

As a future goal for Parametrix, we plan to improve the learning environment by further integrating Generative AI into the process to create a more personalized learning experience, similar to other parametric design approaches that emphasize user customization and agency [7]. This model would build on recent advancements in algorithmic thinking and AI-driven tools for learning parametric design. Our main focus is on producing a model that can generate guidelines- similar to the booklets in the tutorial sections- which guide the user on how to create a particular design they desire parametrically. For instance, when prompted with "Design a rocket body with a 100-unit tall cylinder and cone-shaped nose, then add 4 fins, each 20x10 units" the model will respond with a framework to build this rocket, but it will do it sequentially and provide the next steps based on the user's progress. This method will both take the user through a proper parametric thinking logic and allow them to think while creating the design rather than monotonously copying instructions, allowing for further learning to occur. As a result, the user will have created a design that is more tailored toward their needs. Similar to other interactive and playful approaches for teaching geometric concepts [1], this new model aims to create a personalized learning environment for digital fabrication students using Parametrix. Additionally, we plan to conduct classroom testing in the near future to evaluate the model's effectiveness in a real-world environment. The classroom testing will be conducted in middle level K12 classrooms, including topics like computer science, physical computing, artificial intelligence and engineering-themed science classes. Moreover, we plan on building a design language to promote computational thinking during the learning process.

3. Conclusion

Simply, Parametrix presents an innovative approach to teaching parametric design principles through an accessible web-based platform. By integrating guided tutorials with a flexible workspace environment and leveraging natural language processing for geometric manipulation, the platform effectively reduces the learning curve traditionally associated with the parametric designing technique. So, unlike traditional resources, it provides an introduction from the ground up to Parametric designing. Aligned with constructionist principles, Parametrix fosters hands-on experimentation, encouraging students to actively engage with parametric design concepts. Also, it aims not to be a tool that replaces traditional computer aided design software, but a resource for quick prototyping and parametric design education. Parametrix will continue to evolve, with future developments focusing on

AI-driven personalization to further enhance the learning experience.

References

Shaghaghian, Z., Yan, W., & Song, D. (2021). *Towards learning geometric transformations through play: An AR-powered approach.* arXiv preprint arXiv:2106.03988. https://arxiv.org/abs/2106.03988

Agirbas, A. (2018). *The use of metaphors as a parametric design teaching model: A case study.* Design and Technology Education: An International Journal, 23(1), 40-54. https://files.eric.ed.gov/fulltext/EJ1171595.pdf

Bi, Z. (2013). *Teaching of parametric modeling methodologies for undergraduate engineering students.* Department of Engineering, Indiana University Purdue University Fort Wayne.

http://www.wseas.us/journal/pdf/education/2013/015710-107.pdf

Agirbas, A. (2020). *A teaching methodology for parametric design: A case study with parametric bench.* In *Proceedings of the XXIV International Conference of the Iberoamerican Society of Digital Graphics (SIGraDi)*, 8(4). https://www.researchgate.net/publication/347214328_A_Teaching_Methodology_for_Parametric_Design_A_Case_Study_with_Parametric_Bench

Schnabel, M. A. (2007). Parametric designing in architecture. In A. Dong, A. V. Moere, & J. S. Gero (Eds.),

Computer-Aided Architectural Design Futures (CAADFutures) 2007. Springer, Dordrecht. https://www.researchgate.net/publication/30874784_Parametric_Designing_in_Architecture

McElroy, L., & Huang, L. (2023). *PotScript: A visual grammar for sculpting with functions.* In *SCF '23: Proceedings of the 8th ACM Symposium on Computational Fabrication* (Article No. 9, pp. 1-9). ACM. https://dl.acm.org/doi/10.1145/3623263.3623357

Goodman, J., & Wemhoener, R. E. (2024). *Interactive modules using parametric design: A research study on how parametrically designed, prefabricated modules encourage interactivity and creativity within an urban context.* In *C&C '24: Proceedings of the 16th Conference on Creativity & Cognition* (pp. 43-50). ACM. https://dl.acm.org/doi/10.1145/3635636.3664267

McElroy, L., Bolsée, Q., Peek, N., & Gershenfeld, N. (2022). SVG-PCB: A web-based bidirectional electronics board editor. *SCF '22: Proceedings of the 7th Annual ACM Symposium on Computational Fabrication*, 11, 1–9., https://dl.acm.org/doi/10.1145/3559400.3562004