Educating Designers For Generative Engineering (EDGE)

2022 Advisory Board Meeting Report

Click Here for the NSF Project Page

Prepared by:

Dr. Zhenghui Sha zsha@austin.utexas.edu
Dr. Darya L. Zabelina dlzabeli@uark.edu
Dr. Molly H. Goldstein mhg3@illinois.edu
Dr. Onan Demirel onan.demirel@oregonstate.edu
Dr. Charles Xie charles@intofuture.org
Xingang Li xingang.li@utexas.edu
John Z. Clay jzc298@utexas.edu

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Project Overview

Key Personnel

Dr. Zhenghui Sha, University of Texas at Austin, Principal Investigator

- Dr. Zhenghui Sha is an Assistant Professor in the Walker Department of Mechanical Engineering at the University of Texas (UT) at Austin. His research focuses on system science and design science as well as the intersection between these two areas, with an emphasis on design theory, human-machine interaction, swarm manufacturing, and complex sociotechnical systems.

Dr. Darya L. Zabelina, University of Arkansas, Co-Principal Investigator

- Dr. Darya L. Zabelina is an Assistant Professor of Psychology at the University of Arkansas. Her research focuses on understanding creative cognition, imagination, and other related processes, and how these processes are linked with more traditional subfields of cognitive psychology, such as attention and executive functions. The long-term objective of Dr. Zabelina's research is to create a theoretical foundation upon which to develop methods to enhance creative thinking and problem-solving abilities.

Dr. Molly H. Goldstein, University of Illinois Urbana-Champaign, Co-Principal Investigator

- Dr. Molly H. Goldstein is a Teaching Assistant Professor in Industrial and Enterprise Systems Engineering at the University of Illinois. Her research focuses on student designer trade-off decisions through the study of their design actions and thinking. Her studies often involve educational and professional contexts with cross-disciplinary collaborations.

Dr. Onan Demirel, Oregon State University, Co-Principal Investigator

- Dr. Onan Demirel is an Assistant Professor of Mechanical Engineering at Oregon State University. His research focuses on understanding human elements in the design process, and developing multi-disciplinary design theory and methods to explore inter-dependencies and co-evolution of the human element in engineering systems. His goal is to develop computational and experimental human-centered design theory and methodology to incorporate human factors engineering principles early in the design for product development.

Dr. Charles Xie, Institute for Future Intelligence, Co-Principal Investigator

- Dr. Charles Xie is the founder, President, CEO, and Chief Scientist of the Institute of Future Intelligence. His current work is focused on evolutionary computation algorithms that can be used to create artificially intelligent design tutors embedded in CAD and CAE software. He is also the creator of Aladdin, Energy2D, iFlow, Infrared Explorer, and Quantum Explorer, and a co-developer of Infrared Street View and Telelab.

Xingang Li, University of Texas at Austin, Student Researcher

- Xingang Li is a Ph.D student in the System Integration and Design Informatics Laboratory, studying under Dr. Zhenghui Sha. His research focuses on generative design and human-AI design collaboration.

John Z. Clay, University of Texas at Austin, Research Assistant

- John Z. Clay is a post-undergraduate Research Scientist Assistant in the System Integration and Design Informatics Laboratory, working under Dr. Zhenghui Sha. His research focuses on creativity and engineering systems thinking.

Goals and Research Questions

Project Goals: To define, implement, and disseminate **generative design thinking** to facilitate the teaching and learning of generative design at undergraduate levels.

- *RQ1.* **Theoretical perspective:** What are the essential elements of generative design thinking that students must acquire in order to work effectively at the human technology frontier in engineering?
- *RQ2.* **Practical perspective:** To what extent and in what ways can the project products support the learning of generative design as indicated by students' gains in generative design thinking?
- *RQ3.* **Affective perspective:** To what extent and in what ways can AI affect the professional formation of engineers as indicated by the changes of students' interest and self-efficacy in engineering?

Work Plan

Define generative design thinking by assimilating computational thinking to augment and reshape design thinking, thereby setting up 1) a theoretical foundation for research, 2) learning goals for students, and 3) the developmental goals for the project.

Develop the open-source Aladdin software with the goal to support the learning and teaching of generative design. The focus is on supporting students as they learn basic concepts of generative design, and allowing researchers to find ways to improve this human-AI collaboration.

Develop curriculum modules in Aladdin using project-based learning. To engage students, we will adopt authentic engineering projects that can be realistically solved using generative design.

Conduct educational research through collaboration with ten other participating colleges and universities. With these collaborators, we will explore the strategies and methods for integrating instructional modules and embedding the educational research into introductory engineering and CAD courses.

Collect and analyze student data using instruments such as demographic surveys, questionnaires, self-efficacy measures, design reports, screencast videos, software logs, classroom observations, and participant interviews.

Disseminate the products of this project, including an operational definition of generative design thinking, the Aladdin software, and the instructional modules.

Collaborate with the Advisory Board to evaluate and advance the project through the evaluation given by the board members.

Research Activities

1. **Exploration of data-driven methods** for the **realization of generative design** in support of software and tool development.

In Year 1, we developed a new data-driven generative design approach (Li et al., 2021. Part-Aware Product Design Agent Using Deep Generative Network and Local Linear Embedding) to explore different ways of realizing generative design that has the potential to enhance Aladdin's intelligence and versatility. We continued this effort in Year 2 and have developed a predictive and generative design approach for 3D shape generation in support of human creativity in the conceptual design of product shapes (Li et al., 2022. A Predictive and Generative Design Approach for 3D Mesh Shapes Using Target-Embedding Variational Autoencoder). The approach is built on the proposed target-embedding variational autoencoder (TEVAE) neural network architecture, which consists of two modules: 1) A training module with an E^2D network that has two encoders and one decoder, and 2) An application module performing generative design functions, such as shape reconstruction, interpolation, random generation of new 3D shapes, and a prediction function (i.e., 3D shape prediction from 2D silhouette). See **Figure 1** for more detail. We demonstrated the utility of the proposed approach using 3D car models. The results showed that our approach can learn two latent feature representations, one of which can generate a large number of novel 3D shapes, and the other one can predict 3D shapes purely based on the 2D silhouettes from user inputs.

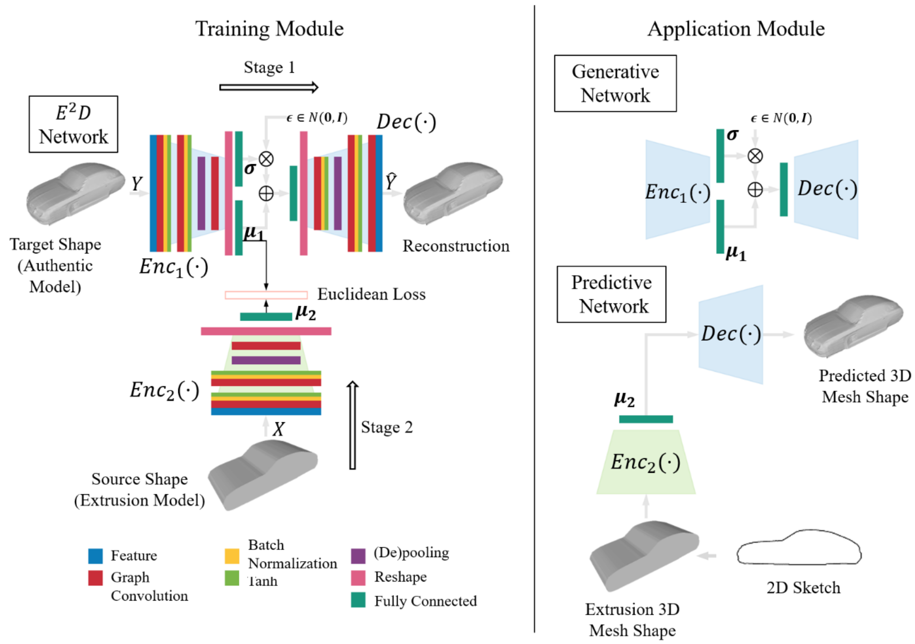


Figure 1: The proposed approach following target-embedding variational autoencoder (TEVAE) architecture (Li et al., 2022. A Predictive and Generative Design Approach for 3D Mesh Shapes Using Target-Embedding Variational Autoencoder).

2. The **design and development of Aladdin**, an open-source computer-aided generative design and engineering software, with the goal **to support the learning and teaching of generative design**.

In Year 2, we made a great effort to develop the cloud-based, open-source Aladdin CAD/CAE software for engineering design research and education. The cloud-based Aladdin has enabled several key features, including a virtual heliodon for visualizing the sun paths at different latitudes and seasons, the ability to model different types and sizes of trees, support for solar array design, and the use of Google Maps as an engineering design canvas. You can access Aladdin through this link: https://intofuture.org/aladdin.html. **Figure 2** shows the web interface of Aladdin as it demonstrates the solar radiation intensity received by the five sides (top, west, east, south, and north) of a box. An interactive graph displays the daily sensor data for comparison of the solar radiation that shines on the five sides. For the generative design features, we plan to build its AI engines based on evolutionary computation methods such as multi-objective genetic algorithms. Work has begun with building a kernel of genetic algorithms with various capabilities such as the local and global search for photovoltaic solar farm design and concentrated solar power design (see **Figure 3**).

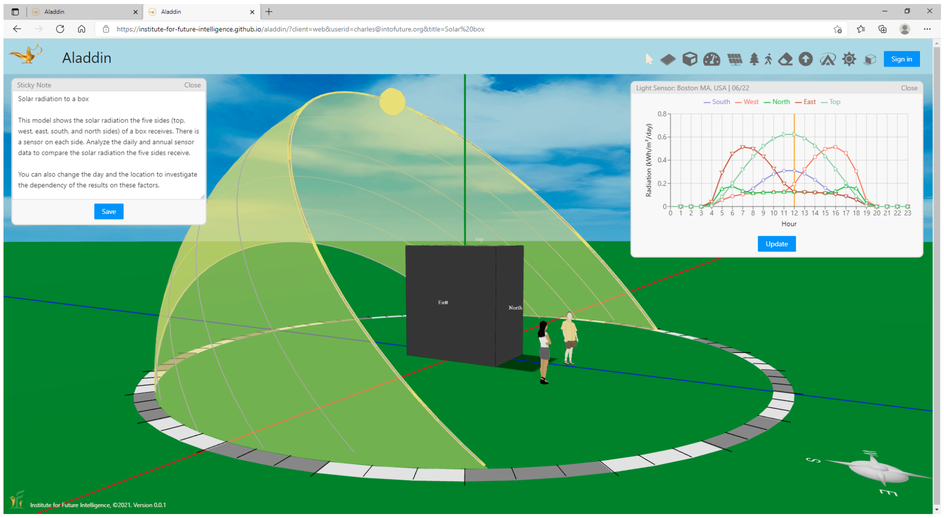


Figure 2. Cloud-version of Aladdin: the daily results of solar radiation on different surfaces of a box.

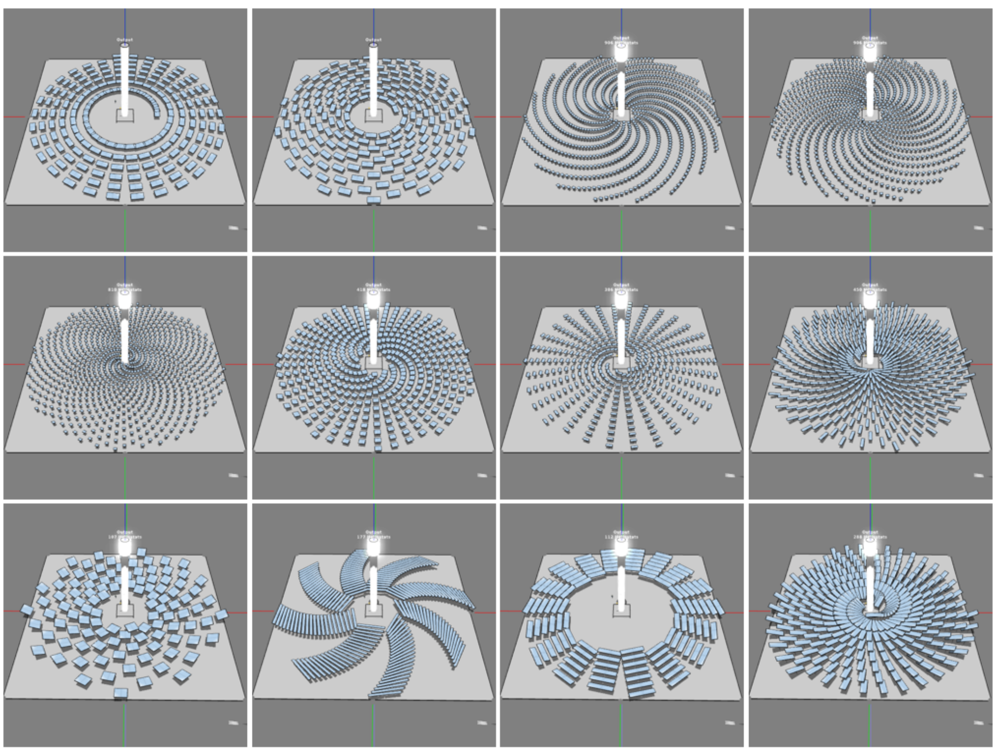


Figure 3. Generative design of concentrated solar towers using Genetic Algorithms.

3. Investigation on the relationship between engineering systems thinking, parametric design thinking, computational thinking, and engineering design thinking in **seeking an operational definition of generative design thinking** (GDT).

We conducted a literature review on several design thinking concepts that potentially have a close relationship with GDT: engineering systems thinking (EST), parametric design (PD), and computational thinking (CT). By studying the constituents of these design thinking concepts and their associated cognitive underpinnings, we hope to identify the basic constituents of design thinking in the generative design process. To this end, we proposed an Evolving Design Thinking (EDT) model (Li et al., 2022. Exploring Generative Design Thinking for Engineering Design and Design Education) that illustrates the relationship among different design thinking concepts, as well as the relationship between these thinking concepts and design technologies, and cognitive competencies (see **Figure 4**). Through literature review, we discovered that a decent amount of research has been conducted to understand the relationships between traditional design thinking and human cognitive competencies to better understand designers and aid them for better design. However, for generative design, the literature has been primarily focused on developing efficient and effective design methods and tools. To our knowledge, little research has been conducted on understanding the essential cognitive constructs and competencies that form generative design thinking. We plan to address this gap with our future research.

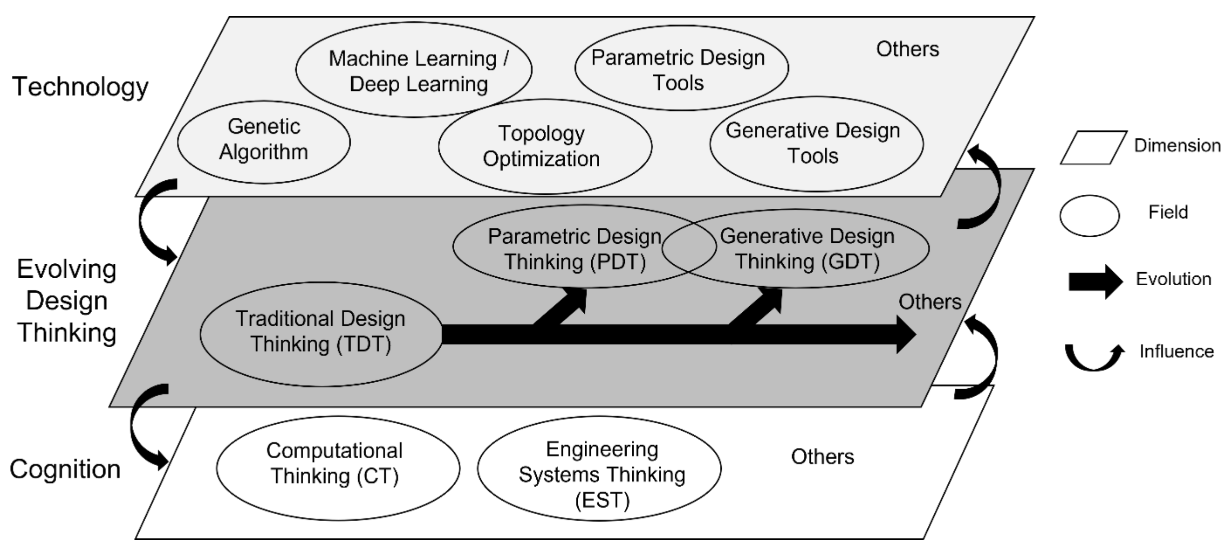


Figure 4: The proposed Evolving Design Thinking (EDT) model (Li et al., 2022. Exploring Generative Design Thinking for Engineering Design and Design Education).

4. The **design and refinement of** the design challenge-based **human-subject experiment** for the collection of design data and designers' behavioral data using Aladdin.

In Year 1, a systems design challenge was presented to participants in which they were asked to design a solar energy system for a local university campus by using the area on a dormitory rooftop, and the adjacent parking lot (Clay et al., 2021. Modeling and Profiling Student Designers' Cognitive Competencies in Computer-Aided Design). In Year 2, we expanded the design challenge to include additional design tasks and goals (Clay et al., 2022. From Design Cognition to Design Performance: A Clustering-Based Correlation Analysis). To complete the Year 2 design challenge, participants worked in a CAD model of a local geographic location to achieve two sets of goals. In Part 1, designers were asked to provide at least two different construction plans for a student housing complex that met several goals (budget, size, etc.). For added design complexity, participants were given a set of constraints to work within. Upper and lower limits were set on: the height of building stories, the height of the windows, the total wall area covered by windows, the number of doors per building, and the size of the doors. For Part 2, participants designed a solar energy system in the adjacent parking lot to generate at least 650,000 annual kWh, under a budget of $950,000, and with a payback period of fewer than 10.5 years. See **Figure 5** for the CAD model that participants designed in.

The data collected from the design challenge enabled our investigations into the relationships between systems design cognition, systems design process behavior, and the performance of a systems design solution. We formulated three research questions: 1) After grouping designers by similarities in their systems design cognition, do the groups behave significantly differently in their systems design process behavior or systems design artifact performance? 2) After grouping designers by similarities in their systems design process behavior, do the groups have significantly different systems design artifact performance or systems design cognition? And 3) After grouping designers by the performance of their systems design artifact, do the groups show significantly different systems design cognition or systems design process behavior? We developed a framework for a comprehensive approach to studying these relationships within engineering systems design. Using a machine learning approach consisting of k-means, hierarchical, and spectral clustering, and an adjusted median split, designers were grouped by their similarities for the three types of data (systems cognition, systems design process behavior, and systems design artifact performance). Results suggest that systems design cognition is related to how designers engage in the systems design process. It was also found that participants who designed high-performing artifacts showed significantly higher divergent thinking of creativity when compared to designers who submitted a low-performing systems design artifact.

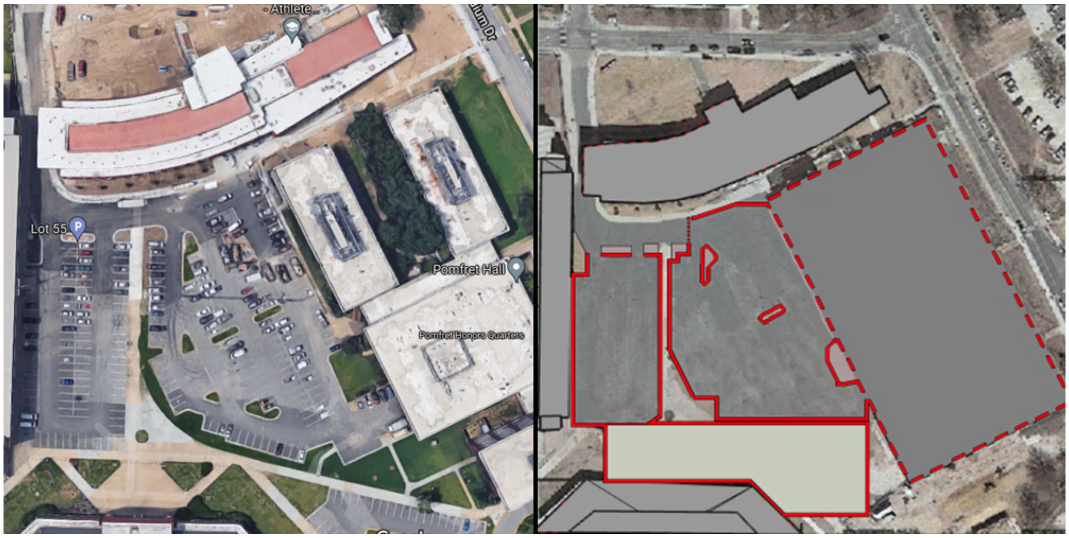
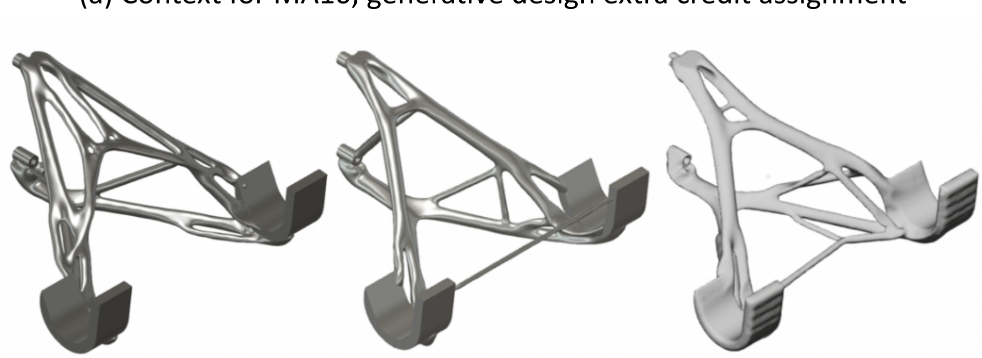


Figure 5: The computer-aided design (CAD) model that was developed. Left: a Google Maps image of the area designers worked in. Right: A top-down view of the corresponding Energy3D model (Clay et al., 2022. From Design Cognition to Design Performance: A Clustering-Based Correlation Analysis).

5. **Preliminary design of curriculum modules** based on existing generative design technologies offered by Fusion 360 in collaboration with our industrial partner from Autodesk Inc. **Data collection and analysis of students' learning data** collected using the Fusion 360 based generative design lab modules.

In Year 1, we began the exploration of integrating generative design technologies in existing design courses. In collaboration with our industrial partner from Autodesk Inc., we developed instructional modules that support project-based learning of generative design. We continued this effort in Year 2 by developing a new course module for an introductory design and graphics course that is required for agricultural, biological, industrial, and systems engineering students. This course aims to introduce students to the design process, including the communication of design ideas generated through hand-sketches and produced in Fusion 360. At UIUC, students engaged in the human-centered design process in a semester-long team design project. As part of the course, students complete nine individual modeling assignments (MAs) in order to learn Fusion 360. The final required assignment (MA9) served as an introduction to generative design and stress analysis. An extra credit assignment (MA10) investigated students' generative design thinking by analyzing their approach to an open-ended engineering design task (see **Figure 6** for more detail). During Year 2, 202 students completed the introductory generative design module (MA9), while 18 students completed the generative design thinking module (MA10). The goal is to uncover generative design rationale in the undergraduate classroom. The work-in-progress results suggest that students are likely to cite rational reasoning in design decision-making between generative design solutions. When comparing their own sketches to the computer-generated solutions, students are still rational in their responses but might engage in intuitive and emotional thinking (Leake et al., 2022. Chapter 15: Simulation. In Engineering design graphics: sketching, modeling, and visualization).

(a) Context for MA10, generative design extra credit assignment



(b) Three example solutions provided by the generative design engine in Fusion 360.

Figure 6: New course material developed in an introductory design and graphics course.

6. **Results dissemination** to major technical and educational conferences as well as peer-reviewed journals.

We have shared the outcomes of our project, including an operational definition of generative design thinking, the Aladdin software, and the instructional modules, to the community of both four-year colleges and K-16 engineering educators through various channels, including online education division, partner websites, conference presentations, and journal publications. Due to the restrictions caused by COVID in the past two years, our intellectual output has been primarily disseminated through online means so far, such as publications and conference presentations. See the **Products** section on pages 13-15 for more details on the publications that have resulted from this project.

Key Outcomes

Released a preview of **cloud-based Aladdin**, thereby laying the foundation for the beta version of Aladdin to be released to the public early next year (https://intofuture.org/aladdin.html).

Developed **a new data-driven generative design approach** based on a new target-embedding variational autoencoder (TEVAE) neural network architecture, enabling students to generate 3D product shapes directly from their 2D sketches (Li et al., 2022. A Predictive and Generative Design Approach for 3D Mesh Shapes Using Target-Embedding Variational Autoencoder).

Proposed an **Evolving Design Thinking (EDT)** model that studies the relationships between engineering systems thinking (EST), parametric design thinking (PDT), and computational thinking (CT), as well as the relationships between their associated cognitive underpinnings, design theories, and technologies (Li et al., 2021. Exploring Generative Design Thinking for Engineering Design and Design Education).

Refined and extended the computer-aided design challenge in support of the data collection for our future Aladdin-based generative design educational platform (Clay et al., 2022. From Design Cognition to Design Performance: A Clustering-Based Correlation Analysis).

Developed **a framework for studying the relationships between systems design cognition, systems design process behavior and the performance of a systems design artifact** (Clay et al., 2022. From Design Cognition to Design Performance: A Clustering-Based Correlation Analysis)**.**

Created **new instructional materials** using Autodesk's Generative Design software to support project-based learning of generative design and collected and analyzed **students' learning data to study their generative design rationale** (Leake et al., 2022. Chapter 15: Simulation. In Engineering design graphics: sketching, modeling, and visualization).

Impact

The development of the cloud-based Aladdin has demonstrated how **Aladdin is enabling engineering design of renewable energy solutions for everyone** in the browser. There are also many other features that we have not introduced in this report. For example, Aladdin allows the designer to store their files on the cloud and open them later on any device. This eliminates the need to rely on a particular computer, thus enabling renewable energy browser-based CAD for everyone.

The new data-driven generative design approach, based on the target-embedding variational autoencoder (TEVAE) neural network architecture can **support students' decision-making in conceptual design**, and will **support the later development of generative design engines in our CAD software** in addition to evolutionary computation methods such as the genetic algorithms. The realization of this system will yield several other benefits. First, it automates the 2D-to-3D reconstruction process, allowing designers to allocate additional time and labor to design iteration and ideation. Second, all 2D sketches created during the conceptual design phase can be evaluated against the desired engineering performance in 3D form. This ensures that the designs that would have a better performance will not be ruled out too early when performance-driven decisions (i.e., rational decisions) are not yet obtained. Third, non-experts will not be discouraged to show their design ideas merely due to the lack of CAD experience or sketching skills. This may have significant educational implications for training novice designers. Lastly, enterprises may use this system to enable user interface to solicit consumer preferences for design customization.

The research on studying students' generative design rationale has a potential impact on **teaching students' trade-off design decision-making**. For example, the concept of design trade-offs or the Pareto frontier might be effectively taught using generative design solutions and their visualizations. Also, in studying the relationships between systems design cognition, systems design process behavior, and systems design performance, many benefits can be gleaned from illuminating the design cognition of high-performing designers. For example, the research could be used to guide the feedback or instructions that designers receive while engaging in a design task. As the relationships between designers' cognitive profile, process behaviors, and design artifacts within systems design are made clear, behavior from one domain may be used to predict or guide the behavior in another. If the designers' cognitive profile is detectable through design process behaviors, by analyzing these behaviors, the designers' thinking patterns can be predicted and guided through curated artificial intelligence (AI) assistance and recommendation.

Lastly, as indicated in our Year 1 report, design thinking is one of the most important topics in design education and design theory. According to Dinar et al., 2015 (*Empirical Studies of Designer Thinking: Past, Present & Future*), "there are still no standards for designing, collecting, and analyzing data." The lack of research platforms that can be freely accessed is a major hurdle for design research, and is the cause of serious issues on research repeatability and reproducibility. Our work on the development of Aladdin software has the potential to generate a profound impact on the domain of design thinking study because it will **support the collection of standard and quality design behavioral data**. The open-source commitment of this platform will broaden its impacts.

Future Work

Software Development: Aladdin

We expect a beta version of Aladdin to be released to the public early next year, which will provide a research and education platform at the intersection between AI and design. Based on the beta version of Aladdin, we also plan to explore the proposed concept of visual programming, a block-based programming environment that allows students to specify the parameters and objectives as the inputs to the AI engines and connect different software modules to control the generative design process.

Approach Development: Generative Design

In Year 3, we plan to continue the development of novel data-driven generative design approaches and will build a user interface to support students in exploring the power of AI in generative design and support their learning of generative design in conceptual design and creative design.

Curriculum Development: Project-Based Learning Modules

We will continue to test the two developed generative design modules with approximately 200 undergraduate students. Moreover, the UIUC model will be used as the basis for other collaborating institutions, such as Oregon State University, to develop their own instructional modules to support the training of Generative Design Thinking as well as to support the data collection for the proposed education research. We will pilot using generative design in a product dissection design project to understand how students perceive product improvements with the help of generative design capabilities. Finally, Co-PI Dr. Goldstein is co-authoring an engineering graphics and design textbook that will include a workflow for generative design in a simulation chapter.

Education Research: Evolving Design Thinking

In Year 3, we will continue investigating RQ1: What are the essential elements of generative design thinking that students must acquire in order to work effectively at the human-technology frontier in engineering? To answer this RQ, we will continue improving the EDT model and exploring the competencies and psychological constructs for GDT. The understanding of GDT could guide the design of generative design curricula to facilitate the engineering education in schools and universities and professional training of generative design in the industry to cultivate successful generative designers. Additionally, we will continue researching students' generative design rationale. In Year 2, we found that students tended to cite rationalistic reasoning in design decision-making, rather than relying on intuition or on empathy for users. Future work will explore the relationship between traditional undergraduate engineering design task decision-making and generative design decision-making.

Research Dissemination

All involved institutions will collaborate with each other to pilot-test the software, modules, and instruments with students at UT, UA, UIUC, and OSU. As the development of the open-source Aladdin software, particularly its generative design module, becomes more mature, we will begin to collaborate with the participating colleges for the dissemination of the software product and instructional materials.

Products

Books and Book Chapters

Leake, James M., Goldstein, Molly H., & Borgerson, Jacob L. Chapter 15: Simulation. In Engineering design graphics: sketching, modeling, and visualization, 3rd Edition. John Wiley & Sons, 2022. ISBN: 978-1-119-49238-2.

Journal Publications

Li, X., Xie, C., & Sha, Z. (2022). A Predictive and Generative Design Approach for Three-Dimensional Mesh Shapes Using Target-Embedding Variational Autoencoder. *Journal of Mechanical Design*, *144*(11), 114501. https://doi.org/10.1115/1.4054906.

X. Li, Y. Wang, & Z. Sha. Deep-Learning Methods of Cross-Modal Tasks for Conceptual Design of Engineered Products: A Review. *Journal of Mechanical Design*. *Under review*.

X. Li, C. Xie, & Z. Sha. Performance-Driven Part-Aware 3D Shape Generation Using Deep Generative Model and Locally Linear Embedding. *Design Science*. *Under revision*.

J. Clay, X. Li, M. H. Rahman, D. Zabelina, M. Goldstein, C. Xie, & Z. Sha. From Design Cognition to Design Performance: A Clustering-Based Correlation Analysis. *Design Studies*. *Under reparation*.

Refereed Conference Papers

X. Li, Y. Wang, & Z. Sha, "Deep Learning of Cross-Modal Tasks for Conceptual Design of Engineered Products: A Review," ASME 2022 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, St. Louis, Missouri, Aug. 14-17, 2022.

M. H. Goldstein, J. Sommer, N. T. Buswell, X. Li, Z. Sha, & O. Demirel, "Uncovering Generative Design Rationale in the Undergraduate Classroom", 2021 IEEE Frontiers in Education Conference (FIE), Lincoln, Nebraska, Oct. 13-16, 2021.

J. Clay, X. Li, M. H. Rahman, D. Zabelina, C. Xie, & Z. Sha, "Modeling and Profiling Student Designers' Cognitive Competencies in Computer-Aided Design", The 23rd International Conference on Engineering Design, August 16-20, 2021, Gothenburg, Sweden.

M. Rahman, C. Xie, & Z. Sha, "Design Embedding: Representation Learning of Design Thinking for Clustering Design Behaviors", ASME 2021 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, Virtual Conference, Aug. 17-20, 2021.

X. Li, M. H. Goldstein, O. Demirel, & Z. Sha "Exploring Generative Design Thinking for Engineering Design and Design Education", 2021 ASEE Midwest Section Conference, Virtually hosted in Fayetteville, AR, Sep. 13-15, 2021.

X. Li, C. Xie, & Z. Sha, "Part-Aware Product Design Agent Using Deep Generative Network and Local Linear Embedding", The 54th Hawaii International Conference on System Science (HICSS), January 5-8, 2021, Kauai, HI.

J. Clay, M. H. Rahman, D. Zabelina, C. Xie, Z. Sha, "The Psychological Links between Systems Thinking and Sequential Decision Making in Engineering Design", The Ninth International Conference On Design Computing and Cognition (DCC), 29 June – 1 July 2020, Atlanta, GA.

Conference Abstracts and Posters

X. Li, Z. Sha, "Human-Supervised Deep Generative Design Framework for Conceptual Design of Product Shapes," DTM Broader Participation (B-Part) Fellows and Student Poster Session, ASME 2022 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, St. Louis, Missouri, Aug. 14-17, 2022. (Top-ten abstracts and won the Travel Award).

Z. Sha, D. Zabelina, M. Goldstein, O. Demirel, C. Xie, J. Clay, A. Brown, J. Standridge, X. Li, M. Rahman, S. Srinivasan, "Educating Generative Design in Engineering", 2022 IUSE Summit – Propelling Change: Moving from Strategy Toward Effective & Equitable Undergraduate STEM Education, Abstract and Poster Presentation, June 1-3, 2022, Washington DC.

X. Li, Z. Sha, "3D Mesh Shape Generation for Additive Manufacturing from 2D Sketches," 2021 CAMDI Research Symposium, Lightning Talks & Poster Presentation, University of Texas at Austin.

X. Li, C. Xie, Z. Sha, "Generative Design of Authentic 3D Shapes from 2D Sketches Using Target-Embedding Variational Autoencoder", ASME 2021 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, Virtual Conference, Aug. 17-20, 2021. Extended abstract for presentation-only submission to the Special Session: Lightning Talks on New & Revisiting Directions at the 33rd International Conference on Design Theory and Methodology.

X. Li, C. Xie, Z. Sha, "Part-Aware Product Design Using Deep Generative Network", ASME 2020 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, St. Louis, MO, Aug. 16-19, 2020. Extended abstract for presentation-only submission to the Special Session: Lightning Talks on New & Revisiting Directions at the 32nd International Conference on Design Theory and Methodology.

J. Clay, M. H. Rahman, D. Zabelina, C. Xie, X. Li, Z. Sha, "Systems Thinking Factors as Predictors of Success in Engineering Design", The Ninth International Conference On Design Computing and Cognition (DCC), 29 June – 1 July 2020, Atlanta, GA. Poster abstract and presentation. Download the poster here.

Doctoral Dissertation

Molla Hafizur Rahman, "Data-Driven Research on Engineering Design Thinking and Behaviors in Computer-Aided Systems Design: Analysis, Modeling, and Prediction", PhD Dissertation, The University of Arkansas, July, 2022.

Other Products

The cloud-version Aladdin software. Aladdin is an experimental platform for reimagining design in the coming era of AI. The power of Aladdin derives from two different sources: generative design and machine learning, with attaining explainable AI (XAI) to support human-machine collaborative intelligence as an important goal. https://institute-for-future-intelligence.github.io/aladdin.

The Solar Design Contest. In an effort to prepare next-generation engineers to be skillful system designers and system thinkers, a design challenge was created to mimic the problems that professional designers might face in an industry setting. The design challenge provided student designers with a space to supply sequential, high-dimensional design process behavior alongside a finely documented solution to the design problem. Participants also completed several psychological tests, which allowed us to study the relationships between systems design cognition, systems design process behavior and the performance of a systems design artifact.

https://sidilab.net/sidi-resources/solar-design-contest-2021-2022/

Password: SiDiLab