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Harvey Mudd College, Claremont, CA, USA

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Gordon G. Krauss

This editorial provides a high-level review of the Clive L. Dym Mudd Design Workshop XIV, *Engineering Design Education and Artificial Intelligence*, held at Harvey Mudd College from May 29 to 31, 2025. In place of the detailed reconstruction of individual presentations and discussions used in some earlier workshop summaries, it records the principal topics of the six thematic sessions and reflects on three successful additions to the workshop format: a third keynote address, an Ideas Marketplace, and a Collaboration Incubator. The editorial then considers whether artificial intelligence should be understood as a design tool, a connected system of tools distributed across the design process, or something closer to a design partner. Particular attention is given to the educational tradeoffs between removing routine work and removing the productive struggle through which students develop skill, understanding, and judgment. The discussion concludes by examining trust, sycophancy, and accountability before turning to the future of design work and the necessarily time-bounded nature of any current conclusions about AI.

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Austin Morgan Kainoa Peters, Jiwon Kim, Şenay Purzer, Aaron Hanai and Charles Xie

This article introduces a new approach to design called conscientious design that promotes and elicits the transformative agency of designers through the conscientious negotiation of risk and benefits. We argue that an emphasis on transformative agency can help designers enact their individualized knowledges, experiences, and values throughout the design process to move towards collective social change. However, an important aspect of bringing about transformative agency through design is to articulate the conscientious negotiation of design decisions through reasoning fluency. In this study, we demonstrate the ways that reasoning fluency promotes transformative agency through college students' design posters situated in a course project to design solar panel installations to help Hawai'i reach carbon neutrality. A qualitative hermeneutic inquiry resulted in five increasingly conscientious levels of design reasoning, ranging from technological determinism as an inhibitor to reasoning fluency to multicultural ingenuity and ethical integrity as promoters of transformative agency. Our findings demonstrate how design can be individually shaped and socially transformed through a conscientious design approach.

Keywords: conscientious design; transformative agency; design reasoning

How do Co-Curricular Interventions Impact Engineering Identity 1448–1456
Pavan Kumar, Oredola Adebayo and Joshua D. Summers

This study explores the impact of co-curricular interventions on undergraduate students' engineering identity (EI), using data from over 2,700 participants across four engineering disciplines. EI comprising Interest, Initiative, Performance/Competence, and Recognition, is modeled using ANN-Crowds, a predictive machine learning framework built from over 18,000 trained neural networks. Findings suggest co-curricular factors uniquely influence all EI dimensions and outperform other critical influencing factors (CIFs) in predictive strength. This research explores statistical alignment in means and consistency across groups while checking for regression based fit to prove their practical robustness. The research provides a strong conclusion that advocates co-curricular programs that enhance student agency and interest, also proposing future work on alternative predictive methods.

Keywords: engineering identity, co-curricular interventions, ANN-Crowds

Your Newest Teammate Needs Training Wheels: AI in Engineering Design 1457–1465
Micah Lande

As generative AI tools like ChatGPT become increasingly accessible, their integration into engineering education demands both critical inquiry and pedagogical experimentation. This study explores the affordances and limitations of large language models (LLMs) in the context of a sophomore-level mechanical engineering course focused on human-centered product design. In a two-phase activity, student teams first generated customer needs and functions independently, then repeated the process using ChatGPT as a design support tool. Students submitted both sets of results and reflected on their experiences. Data sources included design artifacts, written reflections, and semi-structured interviews, all analyzed through qualitative thematic coding. Findings reveal that AI tools reliably expanded idea fluency and structural clarity but offered limited divergent creativity. While students appreciated ChatGPT's speed and coverage, often surfacing overlooked considerations such as safety, maintainability, or systems integration, they also identified outputs as predictable and sometimes misaligned with user context. Notably, students engaged with the tool critically, revising and rejecting suggestions rather than relying on them wholesale. The activity also illuminated prompt engineering as a new form of design literacy. From an instructional standpoint, the educational value of AI was closely tied to how it was framed and scaffolded. When embedded within a reflective and comparative structure, ChatGPT became a catalyst for engineering judgment, not a substitute for it. The study emphasizes the importance of transparency, reflection, and assessment strategies that privilege process over polish. Ultimately, this work contributes to a growing understanding of how AI can support, not supplant, student learning in design education. Generative tools may help novice engineers build confidence and structure during early ideation, but they still rely on human creativity, context-awareness, and ethical discernment. Like training wheels, AI can help students find balance, but the ride remains their own.

Keywords: human-centered design; engineering judgment; generative AI; needs assessment; undergraduate engineering education; project-based learning

Embedding Ethical Audits in AI Engineering Education: A Classroom-Based Intervention to Advance Ethical Reasoning 1466–1482
Pun To (Douglas) Yung

As artificial intelligence (AI) systems increasingly shape engineering design, the ethical responsibilities of future engineers have become more complex. This study presents a classroom-based intervention that integrates ethical audits into a graduate-level, AI-focused engineering design course. Using the Ethical Consideration and Risk Audit Framework for Technology (ECRAFT), students systematically examined stakeholder impact, safety, justice, sustainability, and inclusion within their AI projects. The intervention combined scaffolded instruction, peer critique, and iterative reflection to embed ethical reasoning directly into technical work. Mixed-methods assessment include pre- and post-course surveys, project artifacts, peer audits, and reflective writing. It revealed notable improvements in students' ethical awareness, confidence, and applied reasoning. While students performed well in traditional areas such as safety and risk analysis, they faced ongoing challenges in addressing equity and inclusion. These findings highlight the value of embedded, context-driven ethics instruction and offer a replicable model for enhancing ethical competence in engineering education.

Keywords: engineering ethics education; artificial intelligence (AI), ethical audit; AI ethics; active learning

Curriculum Development and Education Research for Generative Design Thinking 1483–1496
John Clay, Nalin Varma, Zhenghui Sha, Russell C. Reid and Kameron Eves, Molly H. Goldstein and Charles Xie

Generative artificial intelligence (AI) algorithms have recently been applied to engineering design, particularly to explore design spaces which are too large for humans to feasibly comprehend. This paradigm shift from manual human-driven design to automated AI-driven design requires the designer to take a drastically different approach to design-objective space co-evolution during exploration following problem space definition. However, engineering curricula have not yet caught up to the recent rise of generative AI in design (i.e., Generative Design). This paper presents two sets of educational materials developed to teach Generative Design and reports their effectiveness in teaching undergraduate students. Study 1 investigated participant engineering design self-efficacy before and after completing a curriculum workbook developed to teach the fundamental concepts of human-driven and AI-driven design (using genetic algorithms) with CAD project-based learning activities to experience both design paradigms. Study 2 compared performance on a team design activity before (vs. after) students heard a lecture on AI-driven design and completed a topology optimization-based CAD activity. Studies 1 and 2 found beneficial effects of the curricula on students' engineering design self-efficacy and design artifact performance.

Keywords: design thinking; design cognition; engineering design; generative design; design education; self-efficacy

The Transformative Impact of Student Innovation Competitions and Programs on Innovation Mindset 1497–1510
Sadan Kulturel-Konak and Abdullah Konak

Innovation competitions and programs (ICPs) have emerged as pivotal elements in STEM education, providing students with experiential learning opportunities that cultivate technical skills, networking opportunities, and an innovation mindset. However, the literature does not explore ICPs' transformative impact on students' entrepreneurial mindset, which involves profound changes in students' values and abilities. The study posits that participation in these programs significantly enhances students' self-awareness, open-mindedness, and innovation capabilities, which are critical components of an innovation mindset. Semi-structured interviews were conducted with 36 students who participated in various ICPs, using a qualitative inductive approach. Thematic analysis was performed using both human coders and ChatGPT-o3 to identify the strengths and weaknesses realized by students and how their assumptions and beliefs changed during ICPs. The results showed some agreement between human-generated and AI-generated codes, highlighting the role of ICPs in enhancing self-awareness and open-mindedness. Key strengths discovered included communication, leadership, problem-solving, organizational, tenacity, and interpersonal skills. At the same time, common weaknesses included time management issues, communication challenges, a lack of self-advocacy, trust issues, inflexibility, difficulties with conflict resolution, and stress and anxiety. The results also showed that the students became more receptive to careers in innovation and entrepreneurship, leading to a shift in their perceptions of their innovation capabilities.

Keywords: entrepreneurial mindset; innovation mindset; transformative learning; self-awareness; open-mindedness; student competitions; artificial intelligence

How Can AI Help Design? Lessons Learned from Engineering Students and Faculty 1511–1522
Kaela M. Martin, E. Ashley Rea, Akshata J. Balghare and Brian D. Roth

Use of artificial intelligence (AI) has exploded since the introduction of large language models such as ChatGPT. However, it is unclear how students, faculty, and working professionals use AI for professional purposes in this rapidly changing context. We investigated how AI is currently being used among senior design students and faculty at a private Southwestern university. We also surveyed practicing engineers about AI use in their workplace. Student approaches to AI range from avoidance and concerns about plagiarism to enthusiastic adoption as a tutor, research assistant, and co-designer. Faculty have more concerns with the accuracy of AI results and are just beginning to write AI-usage policies for their classes. Industry practitioners express cautious optimism about AI's potential but also emphasize the importance of securing classified or proprietary data and the need for human oversight. Overall, AI-integration into design curriculum is in the early stages but is necessary to properly equip students with the required skills they will need in their careers.

Keywords: artificial intelligence; design practice; design projects

The Socio-economic Dynamics in Artificial Intelligence Development: Power, Privilege, and Poverty in Capital Formation 1523–1533
Jan Auernhammer and Ade Mabogunje

In the creation of variations and the selection of technologies introduced into society, design teams need to form social and economic capital. Designers need to establish social relationships to gain acceptance and influence within social networks, as well as access economic resources. These socio-economic dynamics determine the formation of capital that enables the development of technologies, such as Artificial Intelligence products and services, to address societal needs. Within these socio-economic dynamics, the interactions between diverse societal groups of affluent individuals (power), influential individuals (privilege), and individuals who lack both resource control and influence (poverty) determine who is able to form the necessary capital to develop Artificial Intelligence products and services that address specific societal needs. Understanding these socio-economic dynamics in technology development is particularly relevant for the design and development of Artificial Intelligence, given its significant potential to impact diverse industries and aspects of society. Therefore, this article outlines the socio-economic dynamics that shape the formation of capital in the development of Artificial Intelligence. The article integrates Walter Vincenti's variation-selection theory with human values and need-based design theory, as well as the socio-economic dynamics of capital formation inherent in technology development. By doing so, the article introduces four different types of capital formation, contributing to design theory by providing the socio-economic dynamics that determine whose needs are met through the design of Artificial Intelligence products and services, and who is able to participate in the gaining of social and economic capital. The article informs designers, design educators, policymakers, and decision-makers (particularly those with resource control) about their roles and influence in the Capital Formation for the development of Artificial Intelligence.

Keywords: artificial intelligence; socio-economic dynamics; design; capital formation

Evaluating In-Class Assignment for Graduate Students Using Bloom's Taxonomy-Based PrePostClass Formative Assessments 1534–1543

Reem Khojah and Josephine Relaford-Doyle

The emergence of generative AI tools has raised concerns about academic integrity in higher education, particularly in evaluating coursework and design projects completed outside the classroom. This paper examines moving part of the assessments in-class with the use of Bloom's guided low-stakes formative assessments designed to promote independent thinking and reduce reliance on external genAI assistance. Grounded in the formative assessment principles established by Black and Wiliam in 1998 and aligned with the cognitive levels of Bloom's Taxonomy, the assessments were delivered in-class before and after lectures in a graduate-level bioengineering course. Each session included brief, targeted pre/post class tests focusing on remember, understanding, application, and analysis levels. Participation credit was awarded, ensuring the format remained low-stakes while encouraging engagement. In the context of bioengineering education, where the development of complex design-oriented skills requires cumulative understanding and application, this approach becomes especially critical. These assessments not only track content mastery but also support students' ability to apply and analyze core concepts. These skills are central to the design process, as mapped by Sharunova, Butt, and Qureshi in 2018. Student performance data, survey feedback, and course outcomes were analyzed to evaluate the effectiveness of this strategy. Results showed stronger correlations between pre/post class assessment scores and final course grade performance than with traditional homework assignments. These assessments provide a systematic way to measure graduate-level learning while offering timely feedback that supports student progress. This highlights the value of integrating in-class assessments as a scalable coursework and design method to uphold academic integrity, ensure fair evaluation, and enable responsive teaching, particularly in interdisciplinary and project-based bioengineering environments.

Keywords: Pre/Post Class Assessment; Generative AI (GenAI); In-Class Assessment; Bloom's Taxonomy

Fostering Innovation in Engineering Students: The Role of Generative AI in Engineering Design Class 1544–1556

Daigo Misaki and Komei Miura

In the evolving landscape of engineering education, fostering innovation and creativity has become a critical priority. Traditional Japanese engineering curricula, however, often emphasize technical specialization at the expense of creative problem-solving, interdisciplinary collaboration, and practical design skills. To address these challenges, this study proposes and implements an ambidextrous design education framework that balances exploration and exploitation, which are two complementary dimensions of innovation. The approach is enhanced by integrating generative artificial intelligence (AI), particularly ChatGPT, as a tool for evaluating and supporting student creativity. Building on our previous theoretical framework, this study validates and extends our proposed GPT-based evaluation system through practical implementation in an undergraduate design engineering course at Kogakuin University. This system scores student design proposals along two complementary dimensions: exploitation (refinement, feasibility, and practical implementation of ideas) and an enhanced exploration axis (pursuit of novel, unconventional, and risky ideas), which includes creative potential often overlooked by traditional assessments. Statistical validation revealed significant improvements in both exploration (pursuit of novel and unconventional ideas) and exploitation (refinement, feasibility, and practical implementation) capabilities following AI-assisted design intervention, with moderate to large effect sizes demonstrating practical educational significance. The incorporation of the ''darkness'' element into the exploration axis enhanced assessment sophistication and helped identify creative potential more effectively. Furthermore, this study explores how students perceive and use generative AI and proposes a multimodal interaction model incorporating visual data from students' design process logbooks. This novel interface enables more reflective and embodied co-creation between students and AI. The findings provide empirical evidence that AI-assisted ambidextrous design education can simultaneously enhance creative breakthrough thinking and practical implementation skills, thus offering practical insights into how generative AI can support scalable multidimensional assessment in engineering education.

Keywords: engineering design education; generative artificial intelligence; ambidextrous thinking; exploration–exploitation framework; AI-supported assessment; dark horse prototyping; creativity evaluation

Reframing AI in Education: Generating Design Requirements to Guide The Development of AI Agents to Support Front-End Design Learning 1557–1574

Corey Schimpf, Siddharthsihn Jadeja, Shanna R. Daly, Krina Patel, Jutshi Agarwal, A. Lynn Stephens, Carolyn Giroux, Kara Stark and Leslie Bondaryk

In this work, a team of eight researchers, educators, and designers sought to collaboratively generate a set of design requirements for an AI agent system that could support students to learn about front-end engineering design skills. While there is a wealth of past research on AI in education, there are important gaps in these areas. For instance, work on AI in education has tended to focus on supporting learning in the context of well-defined problems. Our team aimed to explore something more challenging: how an AI agent could support students working with open-ended problems. The larger project involves developing a collaborative web-based platform, Mobile Design Studio (MODS), to support middle school and high school students to engage with front-end design. Results of implementation with students will be presented in future papers. Here, we describe how we generated a consensus-based set of design requirements for the technology developers. Developing consensus was particularly important, given that our team had a wide range of experiences and epistemologies, and the need for a shared vision of what the AI agent would do. We used collaborative autoethnography, where each author is a researcher-participant, both data generator and data analyst. Our design process used an iterative series of reflections and recorded discussions in which we explored how this AI agent could operate to support student learning. Additionally, these reflections considered our social positions and values as educators and researchers, and how these align with the project. In the results, we present (1) themes that emerged from our reflections on how our values aligned with the project, and (2) the results of the consensus design process. The six resulting design requirements address students, teachers, and the AI agent itself, and are linked to relevant learning and design concepts. The discussion highlights common themes and connections among the requirements, including an emphasis on user agency and human-AI collaboration. Finally, for those interested in applying these requirements to other projects, we discuss ethical guidelines to ensure that new systems do not reinforce inequalities among students.

Keywords: front-end design; AI in education; design requirements; collaborative autoethnography

A Framework for Reasoning in Design: Navigating Between Formal, Informal, and Nonformal Strategies 1575–1593

Yakhoub Ndiaye and Jenn Campbell

The mechanism of design reasoning is explored by investigating the potential for its explanation through three modes of formalities: formal, informal, and nonformal. We propose this novel interpretation of design reasoning that extends beyond the predominant inferential strategies traditionally supported by the triple of reasoning classes: deductive, inductive, and abductive reasoning. Utilizing a case study from a developing context, we illustrate how the framework can be applied to analyze the complexities characteristic of design reasoning, in complement to existing classifications, specifically contrasting classic and generative artificial intelligence-supported design processes. The framework's applicability and significance are critically assessed concerning its implications for design practice, education, and research.

Keywords: design cognition; reasoning; mental model; generative AI; design education

A First Prototype: Collaborating with a LLM to Understand Belonging Among Engineering Design Students 1594–1611
Sheri D. Sheppard, Aya Mouallem, Helen L. Chen, Lauren Aquino Shluzas, Gregg A. Muragishi, Susanne Krumme, Richard Quaderer Lizárraga and Nico Henning

This paper presents an exploratory method for using a Large Language Model (LLM) in collaboration with human researchers (HRs) to conduct qualitative analysis of longitudinal interview data. Our case study focuses on belonging among engineering design students in a 9-month long project-based course. We introduce PALS (Person-and-LLM Strategy), a six-step process designed to integrate human expertise with the generative capabilities of a LLM in a rigorous and trustworthy manner. PALS is based on thematic analysis and prior studies that use thematic analysis in combination with LLM technology. We found that credible collaboration with a LLM depends on deliberate data organization, transparent inquiry, and iterative reflection, practices that enhance interpretive rigor. As a result, the LLM contributed not only to coding and categorization, but also to identifying subtler shifts in students' belonging questions across time. These insights add depth to our understanding of how identity, relationships, and task dynamics intersect in project-based learning environments.

Keywords: qualitative research; belonging; Large Language Models (LLMs); engineering design

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