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# BRIDGING THE GAP BETWEEN ENGINEERING AND DESIGN THINKING: HOW TO DEVELOP USER-CENTERED ARTIFICIAL INTELLIGENCE PRODUCT

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**ABSTRACT**
Amid the growing excitement surrounding artificial intelligence business opportunities, developing user-centered AI products has become a critical focus for modern companies. However, traditional manufacturers face significant challenges in this pursuit. This case study explores how to bridge the gap between engineering and design. We examine workshop process of AI-driven products, in which engineers were trained to adopt design thinking, and new tools were introduced to better capture user needs. The findings highlight the challenges encountered during the development of user-centered AI products, along with the proposed solutions to overcome them. The suggestion method offers valuable insights for enhancing the effectiveness of user-centered AI innovation processes.

*Keywords: Artificial intelligence, User-centered design, Design thinking, Engineering mindset transformation, Innovative product development*

## 1 INTRODUCTION

In the current era of artificial intelligence, AI technology plays a pivotal role in product development, reshaping expectations for innovation and market competitiveness. However, traditional engineering approaches, which are often technology-centered and focused on functional implementation, face limitations in AI-driven product development and struggle to meet the diverse needs of users. While AI, as a design material, presents design teams with abundant opportunities for innovation, designers still encounter challenges in demonstrating the return on investment (ROI) of AI functionalities [8]. By collaborating with AI teams, designers and data scientists can drive innovation at both the system and service levels, emphasizing the potential for synergy between design and technology [8].

As AI technology increasingly integrates into everyday life and work environments, the challenge for design and engineering teams is to align technology with user needs in order to create truly valuable and competitive products. The user-centered design approach has emerged as a solution, aiming to understand and address user needs from their perspective, ensuring products are more attuned to users' life contexts. User involvement in the co-creation process is seen as essential to enhancing both the understanding and adoption of AI technologies. The Smart Service Blueprint Scape (SSBS) framework, which maps AI decisions to user interactions, contributes to improving the user experience [7]. Additionally, the integration of interpretable AI visualization techniques effectively bridges the gap in users' technological proficiency, helping them better understand AI-driven decisions and thereby enhancing the overall user experience [6].

The designerly way of thinking not only significantly enhances user satisfaction but also drives product innovation, thereby boosting its market competitiveness. However, during the pursuit of these goals, engineers and designers often encounter collaboration challenges and communication barriers that impede the effective integration of technology development with user experience, ultimately affecting the final product outcome. Research suggests that applying design thinking to closely align AI technology with user needs can facilitate the seamless fusion of technology and design, reducing collaboration challenges between engineers and user experience designers [5].

This study aims to explore how to bridge the gap between engineering and design in the development of AI-driven products, and to address the challenges faced by engineering teams in adopting user-centered design thinking. By proposing practical strategies, the study seeks to achieve the effective integration of technical feasibility and user desirability, ultimately enhancing user satisfaction and market competitiveness. The research objectives are as follows:

1. Conduct a thorough analysis of the key collaboration challenges and communication barriers between engineering and designer in AI-driven product development.
2. Examine strategies to bridge the gap between engineering technology and user experience design, with a particular focus on applying design thinking methods to help engineers shift their mindset.
3. Propose a collaborative framework for integrating AI technology and design and identify potential future research directions.

# 2 LITERATURE REVIEW

## 2.1 Product Innovation in the AI Era

With the rapid advancement of AI technology, designers are receiving new sources of inspiration during the early concept design stages, particularly in areas such as smart cafeterias and online intelligent shopping systems. AI-driven design inspiration enables designers to expand their creative horizons and generate innovative ideas [3]. AI technology not only reshapes the modes of product innovation but also drives designers and technical teams to integrate user feedback more quickly throughout the design process, thereby enhancing product competitiveness [2]. However, these success stories are primarily focused on software products or service industries, with limited research on how AI technology and user centered design can be effectively integrated into hardware products—an area of focus for this study.

## 2.2 Shifting from a Technology-Oriented to a Human-Centered Approach

In technology-driven product development, traditional engineering methods that focus primarily on functional implementation often struggle to meet the diverse needs of users. Therefore, it is essential for engineers to shift their mindset during the development process to gain a deeper understanding of users' needs, cognitive models, and usage contexts [1]. By incorporating design thinking, technical teams can more effectively address the overall user experience. For example, the Smart Service Blueprint Scape (SSBS) framework illustrates how AI-driven decision-making can be integrated with user interactions, encouraging technical teams to adopt a user-centered approach to product design [7].

However, there remains a lack of specific strategies for applying this shift from a technology-driven to a user-centered approach in hardware product development, particularly in how design thinking can be integrated into the hardware technology development process. This study aims to address this research gap.

## 2.3 The Gap Between Engineering Technology and Design

In the collaboration between AI technology and user experience design, bridging the gap between technology and design remains a significant challenge. This is especially critical for users with lower technical proficiency, where improving the interpretability of the technology becomes a key factor. Research indicates that customized visual prompts in product design can enhance users' decision-making abilities [6]. However, these studies primarily focus on software products and do not address how to effectively bridge the gap between technology and design in hardware development. Therefore, further research is needed to explore the application of AI technology in hardware products and to propose concrete strategies for improving user experience in hardware development.

## 2.4 The Application of Design Thinking in Technology Development

Design thinking helps engineers transition from focusing solely on technical solutions to developing innovative designs that address user needs. AI-inspired design, as a tool, encourages technical teams to explore a broader range of solutions [3]. The successful application of design thinking requires engineers

to understand users' mental models and usage contexts, enabling them to make technical decisions that are better aligned with user needs [1].

### 2.5 The Collaboration Framework Between AI and Design

Existing collaboration frameworks between AI and UX design position AI as a creative partner in the design process, helping designers reduce routine tasks and foster innovation [24]. However, challenges such as bias and trust continue to hinder the effective application of AI systems in design. In hardware product development, the practical integration of design thinking with AI collaboration frameworks remains underdeveloped, particularly when addressing conflicts between technology and user needs. Further exploration is needed to overcome these challenges [23].

### 2.6 Overall Review

In summary, while AI technology has driven product innovation, a significant gap remains between technology development and user centered design in hardware products. Most existing literature focuses on the application of AI and the integration of design thinking in software products, with limited practical experience in hardware technology development. Therefore, this study aims to propose suggestions for bridging the gap between engineering and design in AI-driven hardware product development, addressing the research gap in the application of design thinking to hardware development. The goal is to provide technical teams with more concrete and actionable guidelines.

## 3 METHODOLOGY

This section first outlines the selection of the research case and the overall research process. It then provides an overview of the research methods used at each stage. Additionally, the section describes the background of the selected case, the execution process, and the key considerations that guided the organization and implementation of the study.

### 3.1 Research Subject

This study uses the "AI Design Innovation Course Program" which is a collaboration between the design team and one of Taiwan's top five electronics companies, as the research case. The program aims to approach innovation from a "human-centered" perspective, moving beyond traditional "object-centered" thinking and into the world of AI innovation, embracing business opportunities and benefits in the AI era, with a focus on developing innovative concepts for AI products.

The reasons for selecting the "AI Design Innovation Course Program" as the case study are twofold:

1. The research case involves a company that is a partner in the NVIDIA Taiwan AI supply chain, which highlights its leading position in AI technology and related hardware and software development, providing a strong foundation for the research and analysis. This case offers a valuable opportunity to explore how AI laptop product development can be driven by user needs and serves as a case study in AI product innovation.
2. The research case is innovative and reflects the diverse challenges and opportunities of AI-driven product development. The participants come from interdisciplinary backgrounds and were directly involved in developing AI product concepts and proposals. This project not only demonstrates how company develop AI product concepts but also emphasizes user-oriented innovation thinking. Therefore, this case was selected to effectively explore the real-world problems and solutions encountered in the integration of technology, design, and engineer participants to provide empirical foundations and reference value for future similar projects.

The participants in the case study were members of an AI-driven product development project, comprising a total of 24 individuals. Most participants were engineers with backgrounds in software and hardware development. These team members were responsible for technical development and system integration within the project, while senior executives focused primarily on strategic planning and decision-making support.

### 3.2 Research Process

This study draws on practical case experiences, with the research process divided into two stages for data collection. The first stage focuses on the context and application methods of design thinking during the case execution, systematically organizing and analyzing the details of the case implementation. The second stage takes place after the completion of the case, where interviews with relevant stakeholders are conducted to gain an in-depth understanding of their perspectives on the learning outcomes and application of the project. The research emphasizes the interactions among the team members throughout the case process, particularly the challenges and solutions encountered when developing AI products from a human-centered approach.

### 3.3 Research Methods

This study employed three primary methods for data collection and analysis to provide a comprehensive understanding of the research questions:

1. **Participant Observation:** The researcher participated in product development sessions and team meetings to observe interactions during the integration of technology and design. This method allowed for the documentation of communication barriers and challenges, particularly in the practical application of design thinking.
2. **Semi-Structured Interviews:** Interviews were conducted with 21 engineers and 3 senior executives. Table 1 summarizes the participants' teams and roles. The interviews explored participants' roles, experiences, and challenges, with a focus on collaboration issues between technology and design, the introduction of design thinking, and its impact on engineers' mindsets.
3. **Document Analysis:** Project documents, course materials, and meeting records were analyzed to extract key information related to the integration process. This method supplemented the observations and interviews, providing a more comprehensive view of the project's progress.

Table1: Participants' Departments and Roles

| ID | Departments | Roles | ID | Departments | Roles |
|---|---|---|---|---|---|
| **P1** | AI Research Center | Chief Digital Officer | **P13** | Acoustics & Performance | Sensor Team Lead |
| **P2** | R&D | Director | **P14** | Acoustics & Performance | Acoustics Engineer |
| **P3** | Portable Computer | Director | **P15** | AI Research Center | AI Engineer |
| **P4** | Software | Software Engineer | **P16** | Innovation & Design | Hardware Engineer |
| **P5** | Innovation & Design | Sensor Team Lead | **P17** | Innovation & Design | Electronic Engineer |
| **P6** | Innovation & Design | Acoustic Team Lead | **P18** | Innovation & Design | Electronic Engineer |
| **P7** | Innovation & Design | Assistant Manager | **P19** | Software Development | Software Engineer |
| **P8** | AI Research Center | Research Engineer | **P20** | AI Research Center | Manager |
| **P9** | Innovation & Design | Hardware Engineer | **P21** | AI Research Center | Research Engineer |
| **P10** | Innovation & Design | Manager | **P22** | Acoustics & Performance | Validation Engineer |
| **P11** | Digital Center | Senior Data Scientist | **P23** | Innovation & Design | R&D Engineer |
| **P12** | Software | Firmware Team Lead | **P24** | Innovation & Design | Electronic Engineer |

Through the integration of the aforementioned methods, this study aims to systematically explore the challenges faced by engineers in projects and propose effective integration strategies and recommendations. The goal is to enable technical teams to better apply design thinking in AI-driven product development, thereby enhancing user satisfaction and market competitiveness.

## 4 RESULTS

This chapter presents the main findings of the study, based on the analysis of interview data from 24 interviewees, as well as course application materials. Systematically describe the challenges engineers face when approaching product design from a user-centered perspective in AI-driven product development, as well as the current improvements in addressing these challenges.

### 4.1 Course Satisfaction Analysis

Table 2 summarizes the Net Promoter Score (NPS) for the course survey in this study, reflecting participants' overall satisfaction with the course and their intent to recommend it. The total number of respondents was 45, with the majority being promoters (36 participants, scoring 9-10), indicating strong approval and a high willingness to recommend the course to others. Additionally, there were 6 passive participants (scoring 7-8), who expressed a neutral attitude towards the course, while only 3 detractors (scoring 0-6) were recorded, suggesting a low dissatisfaction rate.

The average NPS score was calculated to be 67.98, placing it in the high range of net promoter scores, which demonstrates that the course content was well-received by the majority of participants. Of the 45 survey respondents, 80% were promoters, significantly higher than the 6.7% of detractors. The passive group represented 13.3%, indicating that most participants had a positive response to the course.

Table2: NPS Evaluation Results of the Course Survey

| Category | Item | Value |
|---|---|---|
| Net Promoter Score | Promoters | 36 |
| | Passives | 6 |
| | Detractors | 3 |
| | Average Score | 67.9 |
| Total Respondents | | 45 |

In summary, the course design has proven effective in helping engineers better understand human-centered concepts and innovate in AI product development, providing empirical evidence and valuable insights for this case study.

### 4.2 Feedback on Course Application

Interviewees generally felt that the design thinking course positively impacted their mindset, especially in understanding user needs and market orientation *(P13, P20)*. Tools like personas and customer journey maps helped systematize early product design *(P21, P22)*. However, some engineers found the course too intensive, making it difficult to fully master and apply in their work *(P12, P13)*.

Continuous support and training were seen as essential for effectively applying design thinking, especially when facing technical challenges *(P12, P19)*. Several emphasized that design thinking requires time to internalize through repeated practice to fully integrate user needs into technical development *(P13, P20)*.

In summary, this chapter highlighted the case between engineering and design in AI-driven products and demonstrated the initial impact of the design thinking course. While the course had a positive effect, further practice and support are needed to achieve deeper integration between technology and user experience.

### 4.3 Challenges Faced by Engineers

Interviews show that most engineers face significant challenges in adopting user-centered development. Many lack experience with design thinking, as their training focused on technical development with little emphasis on human-centered design *(P4, P5)*. This creates gaps in applying design thinking, particularly when integrating AI into products, which requires extensive collaboration and convincing stakeholders *(P4)*.

Some suggested that more real-world examples would enhance their ability to apply these methods in daily tasks *(P10, P14)*. Respondents also recommended focusing more on practical case studies in the course to improve real-world application *(P21, P22)*.

Engineers also struggled with shifting from a technology-driven approach to a user-centered one, citing a lack of systematic processes and evaluation frameworks *(P15, P16)*. Tools like personas and customer journey maps were difficult to apply, especially under time pressure and changing market demands (P15,

P16). Balancing technical development with user needs, considering costs and feasibility, posed further challenges *(P4, P5)*. Management support was deemed crucial for the successful adoption of design thinking *(P15, P16)*.

### 4.4 Identification of Communication Barriers

One of the main collaboration challenges between engineers and designers is communication barriers. Many interviewees mentioned that differing understandings of product requirements often led to misaligned design and development goals *(P13, P23)*. Engineers, focused on functionality, and designers, centered on user needs, frequently struggled to make unified design decisions. Additionally, tools like customer journey maps and personas were difficult to apply, further complicating communication *(P3, P10)*.

These barriers significantly impacted the progress and outcomes of product development, especially during the requirements and design phases. The differing priorities between engineers and designers required repeated discussions to reach consensus *(P13, P23)*. Engineers often used technical language, while designers emphasized user experience, leading to further misunderstandings that required coordination to overcome *(P3, P10)*.

Some engineers suggested that the composition of workshop participants could be made more diverse in terms of backgrounds (P3, P13). By engaging in dialogue and understanding each other's ideas, engineers and designers can collaborate more effectively to address challenges in product development. More interaction and mutual understanding would enhance collaboration. Designers also recommended involving technical teams earlier in the design phase to improve alignment and coordination between both sides *(P13, P23)*.

### 4.5 Effectiveness of design thinking

The application of design thinking in the courses helped engineers shift from a technology-driven approach. Many reported a greater focus on user needs, such as considering remote work and voice interaction in product design *(P7, P16)*. AI applications like voice recognition also showed how technology could align better with market demands *(P1)*.

The courses improved engineers' understanding of user-centered design, boosting future innovation *(P6, P8)*. However, challenges remain in balancing innovation with cost control, especially under supply chain constraints *(P1)*. While design thinking enhanced their grasp of user needs, managing both innovation and risk remains difficult *(P7, P16)*.

The courses also raised awareness of user research, enabling better alignment of products with market expectations. Yet, translating user needs into technical requirements still requires more collaboration between engineers and designers *(P7, P16)*.

## 5 DISCUSSION

This chapter examines the research findings from three perspectives: the impact on the case study, a comparison with previous literature, and strategies and recommendations for future research topics. It aims to provide a deeper analysis of the implications of the findings, highlighting their uniqueness and contributions within a broader academic context.

### 5.1 The influence of design thinking course

The results indicate that integrating AI into user-centered product development, along with the introduction of design thinking, had a significant positive impact on engineers' work processes. Tools like personas and customer journey maps helped engineers adopt a user-centered approach, deepening their understanding of user needs. This shift was reflected in their ability to integrate design thinking into daily decision-making. For example, one of interviewees noted that the design thinking course helped engineers shift from a technology-driven to a market-driven approach, better aligning with market demands. *(P1)*

However, challenges remain. Many engineers reported a lack of practical guidance and ongoing support when applying design thinking, particularly in balancing innovation with cost control, especially under supply chain constraints. These challenges highlight the difficulty of implementing design thinking in practice, especially for teams needing to make quick decisions with limited resources. Thus, the study suggests that successful adoption of design thinking requires continuous training and support to effectively merge technology with user experience and remain adaptable in dynamic environments.

Moreover, interviewees noted that design thinking not only improved user experience but also enhanced internal communication. Engineers became more collaborative and better understood designers' perspectives, which had previously been rare. This changes improved team cohesion, allowing for faster responses and adjustments during product development, reducing iterations and resource waste.

### 5.2 Comparison with Previous Literatures

The challenges and opportunities revealed in this study align with previous research on the integration of design thinking and engineering. Raftopoulos emphasized the importance of incorporating user input at every stage of technical development to fundamentally shift engineers' mindsets [2]. This is consistent with the feedback from participants in our study, where design thinking helped engineers better understand and integrate user needs into human-centered product development.

Similarly, Shergadwala and Seif El-Nasr highlighted the importance of considering users' mental models and operating environments during technical development to achieve true user-centered design [1]. This mirrors our findings, as participants emphasized that technology should not merely meet functional requirements but should be based on user interaction needs. These results underscore the importance of deep user understanding and careful consideration of technology application across different product development environments.

However, while research has focused more on how explainable AI enhances user experience, engineers in our study faced practical challenges in applying design thinking and tools [6]. This suggests that in AI product development, beyond the explainability of technology, the practicality and feasibility of design tools must also be emphasized. These challenges indicate that for the successful implementation of design thinking, engineers need ongoing professional training and adequate resource support in their daily development work.

### 5.3 Suggestions

Based on our findings and comparisons, future research should focus on the following directions to promote deeper integration of technology and user experience design:

1. **Continuous Education and Support**: The study highlights the need for ongoing education to help engineers effectively apply design thinking. Establishing a continuous learning system with practical exercises and case studies—supported by company resources and management—is essential. Collaboration with cross-functional teams can create tailored professional development paths, with regular evaluations to ensure practical application.
2. **Enhancing Cross-Disciplinary Collaboration**: The study emphasizes the importance of effective communication between engineers and designers. Future efforts should foster cross-disciplinary collaboration through joint workshops and training to strengthen mutual understanding. Regular cross-departmental seminars and workshops focused on real-world product development scenarios can improve teamwork and collaborative problem-solving.
3. **Practical Application and Case-Based Learning**: Many participants noted the need for more concrete guidance on applying design thinking. Future courses should include more case studies and hands-on exercises to bridge the gap between theory and practice. Utilizing real-world product development scenarios will demonstrate how to apply design thinking tools effectively.
4. **Strengthening the Link Between Technology and Market Needs**: Future research should explore how to better connect technical development with market demands. While design thinking helps engineers understand user needs, incorporating more data and market analysis is required to ensure products meet consumer expectations. Companies should establish feedback

mechanisms and integrate market data into product development to enhance competitiveness and user satisfaction.

Through strategic implementation, the integration of technology and user experience design will become more seamless, enhancing both user satisfaction and market competitiveness. The challenges and opportunities revealed in this study demonstrate the significant potential of design thinking in technical development. However, its success requires adequate resources, cross-disciplinary collaboration, continuous educational support, and practical application guidance. As technology and market demands evolve, the flexible and innovative application of design thinking will be crucial for future product development. These findings provide clear direction for future research and practice, emphasizing the importance of merging technology and design in user-centered product development.

## 6 CONCLUSION

This study highlights the challenges and suggestions in integrating user-centered into AI product development, emphasizing the potential of design thinking to bridge the gap between engineering and design. By analyzing engineers' experiences in AI-driven product development, we demonstrate that design thinking effectively shift engineers' mindsets, enhancing their ability to design from a user-centered perspective. The study underscores the importance of continuous support and cross-disciplinary collaboration.

Academically, this research fills a knowledge gap regarding the application of design thinking in AI and hardware development. From a business standpoint, it provides specific suggestions for tech companies to better integrate design and technology, thereby improving user satisfaction and market competitiveness. In conclusion, the flexible application of design thinking enables technical teams to better understand and meet consumer needs. However, successful implementation requires continuous education, cross-disciplinary collaboration, proper resource allocation, and practical guidance. These factors are crucial for the future success of AI-driven products.

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