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DESIGN THINKING IN PRACTICE: AN INTERNATIONAL CROSS-CASE EDUCATION COMPARISON OF PEDAGOGICAL PATHWAYS

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ABSTRACT
This paper presents a comparative educational case study examining how two differently framed design education projects contributed to student learning and innovation-oriented outcomes within the context of sustainable agricultural technology. The study compares two parallel university courses conducted in the UK and Sweden in collaboration with the agricultural technology company DeLaval. Rather than claiming broad pedagogical generalisations, the paper focuses specifically on how differences in project structure, technological framing, user access, and collaboration influenced student learning processes and design outcomes. The first case involved 11 individual projects completed by Advanced Design Management students at Aston University, where students developed user-centred product–service concepts informed by field visits, interviews, and market analysis. The second case involved five engineering design students at Mälardalen University who developed a virtual reality (VR) assembly-training prototype for the DeLaval VMS V300 milking robot. A cross-case qualitative analysis was conducted using design thinking framework dimensions including scope definition, degree of user engagement, working structure, contextual familiarity, and iteration practices. Findings indicate that open-ended projects encouraged broader conceptual exploration but created challenges in contextual understanding, while technology-constrained projects supported technical depth but limited conceptual diversity. Across both cohorts, limited access to users and unfamiliarity with agricultural contexts affected iteration quality and confidence in decision-making. The findings support a more cautious conclusion that international thematic alignment can enrich reflection and expose students to complementary design approaches when supported through structured interaction and contextual access. The study contributes practical insights for educators designing cross-institutional sustainability-focused design projects.

Keywords: design education, design thinking, design process, agriculture, virtual reality, service design

1 INTRODUCTION
The agriculture industry offers a highly important area where even small innovations can have significant impact. As the largest source of food globally, agriculture has undergone substantial development throughout history, more recently, has experienced increasingly severe labour shortages. With the world's population expected to increase by two billion people by 2050, continuous innovation is essential, creating new educational opportunities that support further advancement. This paper examines two independent international design education projects situated within the broader context of sustainable agricultural innovation, recognising that agricultural practices and challenges are inherently shaped by geographic and cultural contexts. Sweden and the UK are significant contexts in the dairy industry as they represent complementary environments for agricultural innovation. Sweden is strongly associated with advanced, sustainability-driven dairy technology and a high level of automation, driven by innovation-led companies. In contrast, the UK exhibits more diverse farming practices, which shape technology adoption in response to varying farm sizes, labour constraints, and the feasibility of integrating new solutions [1]. In recent years the use and integration of emerging technologies in engineering and design education settings have set a new tone, where integration challenges present complex learning experiences for students, educators, and organisations alike. A user-centred approach

is increasingly important in this context, ensuring that user needs and expectations are systematically integrated throughout the development process.

Prototyping remains a foundational activity in advancing design efforts towards functional and purposeful outcomes. However, it now operates within an increasingly iterative and digitally enabled product development landscape [2]. In recent years, virtual simulations and digital twins have emerged as cost-effective and scalable means of evaluating and refining design concepts prior to physical realisation. In parallel, Extended Reality (XR) technologies, encompassing immersive and interactive digital environments, are reshaping established design practices and challenging conventional prototyping paradigms [3]. When teaching the development of products that incorporate emerging technologies, it is critical to ensure that user needs and expectations are systematically integrated throughout the development process. It is also important to raise awareness of the importance of user-centred approaches as they increase the likelihood that resulting tools are not only technically robust, but also useful, usable and accepted [4,5]. At the same time, there remains sustained interest in understanding how learning processes unfold within complex, multidisciplinary product development projects, particularly in relation to building a shared knowledge base among diverse stakeholders [6]. This study aims to propose the use of a broader educational ecosystem [7], connecting international partners and different approaches for diversity and comparisons linked to design thinking phases [7,8,9], and contextual challenges within the agricultural sector. Thus, this design education initiative showcases how international student cohorts pursuing different user-driven perspectives, can engage through pedagogical and thematically aligned pathways. It further illustrates how opportunities emerged as potential outcomes rather than guaranteed results, and how the degree of facilitation and preparatory setup can influence the extent to which students were able to engage in dynamic, cross-border design processes.

2 METHODOLOGY

This explorative comparative study draws on two independently conducted project-based university courses linked through a shared agricultural innovation theme. To allow for analytical transparency, the comparison was structured using four predefined analytical dimensions: (1) scope definition, (2) user engagement, (3) working structure, and (4) contextual familiarity. Data sources included student reports, reflective documentation, presentations, prototype outcomes, interviews, survey feedback, and instructor observations collected throughout the duration of both courses. By study adopts a qualitative cross-case synthesis approach to identify recurring patterns, contrasts, and pedagogical implications emerging from the two educational settings. The analysis focused specifically on how project framing influenced student iteration practices, stakeholder engagement, and concept development. The study draws on two educational cases: 11 individual projects completed by final-year Product Design Management students at Aston University, and one collaborative XR-focused engineering design project conducted by five fifth-year students at Mälardalen University. Findings are based on project outputs, observations, reflections, presentations, interviews, surveys, and design documentation developed throughout the courses. The methodological approach combines exploratory qualitative inquiry with project-based learning and design research methods, emphasising iterative processes, user-centred design, prototyping, and reflective learning across both educational contexts.

At Aston University, the student project was developed to create innovative product service systems for DeLaval to enhance added value to their products and services in the Advanced Design Management module. The project was conducted over a 12-week period. Learning objectives were established to enhance student ability to apply design as a strategic tool for planning, developing and innovating products and services as part of key design management activities as well as to discuss and analyse design strategy and business elements. The module included lectures on service design, systems-thinking, user-centred design, and a guest lecture covering the dairy industry, dairy cows, milking systems and DeLaval all of which provided useful knowledge for students to carry out their products. It also contained individual activities and tutorial sessions in which students could apply what they learned during lectures and discussed with the tutor. Students were encouraged to apply design thinking, a user-centred approach and iterative design processes that enable continuous improvement [8]. A visit was made to a family-run dairy farm located in Staffordshire, UK in November 2024 to provide students with an opportunity to observe dairy cows, machinery and the environment and to have conversations with farmers. The module comprised two sets of tasks linked to formal assessments as follows: 1) generating creative reports presenting their understanding about product service systems, research findings from both secondary and primary research and proposed design directions accompanied by client presentations; and 2) submitting creative reports demonstrating product and service prototypes developed from insights gained during the research, along with presentation boards. The first and the second tasks were completed in week 7 and week 12.

At Mälardalen University the student project was set to explore Extended Reality (XR) and how it could be made useful within the agricultural sector, more specifically by developing a Virtual Reality (VR) experience capable of supporting assembly training of the DeLaval VMS V300 milking robot. To enable an immersive learning experience, this eliminated the need to handle heavy parts and reduced the risk of injury and equipment damage. The 20 weeklong project experience involved three sprint review sessions, lectures such as typology optimisation and Virtual/Augmented Reality simulation that supported the project-based course setup. Throughout the project students explored different tools that could be used for the design of the VR environment like eDrawing (compatible with Solidworks), Unite (a game engine that requires C# expertise), and Godot (a free game engine enables users to design using fewer complex scripts). Godot was chosen for the development. The project made sustainability considerations where energy efficiency took consideration to the type head-mounted-display that would be preferable, also waste reduction concerning battery lifespan and minimising environmental impact of devices being used. Interviews and a survey were used to collect farmers' experiences and reveal potential constraints or insights for how XR could be of use in their work. The project was assessed based on a) Function verification, b) Material selection, c) Design validation, d) Simplified life-cycle analysis and sustainability analysis, e) Dimensioned construction drawings, f) Validated calculations, g) Oral presentation, and h) Technical report. In combination with the project a separate assignment was needed to complete the overall course. For this, a digital prototyping supporting tool [9], also known as ePST was prepared together with a prototyping reflection report. This assignment was provided for everyone to fill out, outlining the different types of prototyping experiences they each encountered throughout the given project. The ePST template was also assessed according to level of engagement, degree of meaningful content, and its depth and richness.

2.1 Pedagogical exchange

The two case studies were analysed through across four key aspects: scope, user engagement, working structure, and contextual familiarity through a systematic qualitative comparison of the two pedagogical settings. The comparisons are grounded in differences between constructivist, user-centred and experiential learning approaches at Aston and more structured, technology-mediated, system-focused and collaborative pedagogies at MDU. Data were observed from student project outputs, presentations, reflective reports, and also instructor observations as well as student feedback gathered throughout the courses. To support broader reflection and extend students' understanding of the shared thematic area, teachers encouraged informal knowledge exchange between the project groups. Rather than establishing formal collaboration, the initiative was designed as a pedagogical trigger to broaden perspectives through peer-to-peer sharing of experiences, design approaches, and contextual insights. An online workshop was organised in the early project phase, aligned with the empathy and define stages of the design process. During this session, students presented ongoing work, shared initial findings, and discussed conceptual directions and challenges. This enabled comparison of disciplinary approaches, research methods, and interpretations of agricultural contexts. Due to timetable constraints, further structured meetings could not be implemented. Instead, continued interaction was encouraged as a voluntary, student-driven activity beyond the formal course structure. The exchange aimed to strengthen situational awareness and support reflection on how differing farming practices, user contexts, and design methods can influence problem framing and concept development. Overall, the activity functioned as a means of expanding perspectives through interdisciplinary peer learning rather than formal collaboration.

3 FINDINGS

This section outlines the unique project experiences that characterised their respective outputs.

3.1 Aston University projects

In the first task, students demonstrated their understanding about product service systems through literature review, generated findings from secondary and primary research that informed the identification of problem areas and the ideation of products and services. They used various tools for user research and market analysis, such as user personas, user journey map, service blueprint, SWOT analysis and benchmarking. Although students had limited access to people in the dairy sector, four students engaged participants from the dairy sector through interviews to identify user needs and explore potential design solutions. One student actively involved dairy farm owners during the design development, evaluation and iteration stages, while another included participant feedback as part of the design refinement process. A wide range of innovative design concepts and directions incorporating products and services were proposed. Key concepts include: Concept 1) a wearable blood monitor – product and service innovation to help dairy farmers rapidly diagnose and treat illness in cows, Concept 2) a product and service monitoring and preventing water pollution in dairy farms, Concept 3) a comprehensive digital platform tailored for South Asian entrepreneurs interested in scaling their dairy business through automated and efficient dairy farming and Concept 4) a hoof care product that helps maintain healthy hooves and prevent lameness. These initial concepts were further advanced in the second task. In the second task, students presented design outcomes developed based on the design concepts and directions suggested in the first task. Insights obtained from the farm visit and conversation with the farmers were reflected in their development processes. Improvements and refinements were made throughout the processes. Some of the students conducted more research to strengthen their solutions and determine details of their designs.

3.2 Mälardalen University project

To explore the possibilities of how XR can be used in agriculture the aim of promoting the assembly training of the DeLaval's VMS V300 milking robot presents the potential for visuals communicated in a safe manner. Figure 2 provides a simplified version of the milking robot, provides an overview for easy mounting process, addressing details and process steps. Based on interviews and survey feedback collected, the project group gained additional insights that informed the development of the VR-based assembly prototype. One of the primary challenges identified during the design process was the limited screen resolution, which affected the clarity and precision required for designing and assembling individual components within the virtual environment. To support operators during assembly, the prototype incorporated marked "snap zones" that allowed components to be picked up and attached sequentially. New elements were introduced only once the preceding component had been correctly positioned, thereby guiding users through the assembly process. While the implementation of realistic physics in VR proved challenging, iterative refinement led to improvements in the final prototype. In particular, earlier issues such as screws falling off the virtual work surface were resolved, allowing components to remain in place and ready for use. After user testing opportunities for further refinement added to improve the movement and manipulation of individual parts. One of these refinements focused on authentic handling, as this was highlighted by users as a critical aspect for the experience. In addition, feedback suggested that grasping and positioning components could be made more intuitive to better reflect real-world assembly tasks. Given the overall complexity of the system, users also indicated that stepwise instructional support could enhance usability. In more detail, suggestions included the integration of pictorial instructions and visual cues, such as highlighting or illuminating components to indicate which parts should be selected and connected at each stage. Despite the project constraints prevented the full implementation of all suggested features, the findings point to promising directions for future development and demonstrate the value of iterative user-informed refinement in VR-based design environments.

4 ANALYSIS

The presented design phase comparisons provide a structured basis for the subsequent discussion, where pedagogical framings, contextual access, and design constraints are examined. Table 1 presents the cross-case analysis that also highlights the two educational settings that have generated different forms of learning and design exploration rather than directly comparable outcomes. The Aston University projects demonstrated broader divergence in concept generation, largely due to the open-ended nature of the brief and the individual working structure. Students explored a wide range of product–service opportunities, but several projects remained conceptually broad because of limited access to domain-specific stakeholders and time constraints associated with iterative refinement. In contrast, the Mälardalen University project produced a narrower but technically deeper outcome through the development of a VR-based assembly-training prototype.

Table 1. Cross-case analysis

DESIGN THINKING PHASE	Aston University (Advanced Design Management)	Mälardalen University (Engineering Design Project)	COMPARATIVE PEDAGOGICAL INSIGHT	CONTEXTUAL CONTRIBUTION
Empathise	Market analysis, farm visits, stakeholder interviews; service-oriented context exploration	Surveys, interviews on assembly training; workflow analysis	Aston: human-centred exploration; MDU: technical-system focus	Context shapes early problem framing and user inquiry depth
Define	Open-ended opportunity framing from research insights	Constrained brief focused on VR training usability	Aston: broad reframing; MDU: scoped definition	Scope determines design autonomy vs analytical depth
Ideate	Broad concepts (health, pollution, digital services, hoof care)	VR tools, interaction design, training solutions	Aston: conceptual diversity; MDU: technical iteration	Framing influences innovation breadth and direction
Prototype	Conceptual service/product prototypes, presentation artefacts	Functional VR training prototype with interactive features	Aston: conceptual prototyping; MDU: operational system build	Prototyping reflects exploratory vs technical validation
Test	Limited feedback due to access constraints	Iterative user testing of technical design (interaction, guidance)	Aston: direct link to farm user input; MDU: low authentic user feedback loops	Iteration depends on user access and system tangibility
Reflection and Exchange	Online workshop on concepts and approaches	Cross-institutional sharing of VR development experiences	Mainly reflective peer learning	Structured reflection broadens disciplinary awareness
Pedagogical Orientation	Open, user-centred, exploratory design	Constrained, systems and engineering-focused	Complementary pedagogical models	Different framings produce distinct sustainability learning pathways

The constrained technological framing enabled students to focus on implementation challenges, usability refinements, and sequential interaction design within a specific system context. The findings do not provide sufficient evidence to claim that one pedagogical approach is superior to the other. Instead, the cases illustrate how different educational framings influence the balance between conceptual breadth, technical depth, and opportunities for user-centred iteration. Across both institutions, students experienced uncertainty when working within an unfamiliar agricultural context, particularly when attempting to translate user insights into actionable design decisions. The comparative findings therefore suggest that contextual immersion and structured stakeholder access play a significant role in supporting confidence, iteration quality, and design relevance within sustainability-oriented design education. Although the collaboration was not sufficiently extensive to evaluate measurable collaborative learning outcomes, the interaction enabled students to compare disciplinary perspectives, discuss contextual differences between Swedish and UK farming practices, and reflect on alternative design approaches.

Consequently, the paper reframes a purpose-driven, international pedagogical exchange, as an exploratory mechanism capable of supporting reflection and perspective-sharing when appropriately facilitated. Despite these differences, both student groups experienced a common challenge in encountering unfamiliar contexts. Agriculture and dairy farming represented new terrain for most participants. While Aston students received introductory input on dairy systems through a guest lecture and a dairy farm visit, many still reported difficulty identifying novel product–service opportunities within an unfamiliar industry. Furthermore, identifying and engaging potential users and stakeholders within the dairy sector for primary research proved to be highly challenging. Similarly, MDU students experienced uncertainty due to limited contextual access, leading them to focus on controllable and well-defined elements, particularly existing technologies. This underscores the importance of contextual immersion and access to primary users, especially in specialised domains where tacit knowledge plays a central role in shaping meaningful design outcomes [2].

The educators at both institutions attempted to mitigate arising challenges by introducing collaborative sessions, shared project pitches, and joint reflective activities that resonates with research that emphasise structured interaction as a means to broaden perspectives and enhance engagement [3]. Although insight exchange occurred primarily at a conceptual level, early sharing proved valuable in stimulating alternative viewpoints and reinforcing user-centred thinking across both cohorts with Aston students reporting difficulties integrating service design principles, alongside the development of a physical product to address the identified problem, reflecting their stronger background in physical product design. It is therefore questionable how service design literacy is scaffolded within product-focused curricula and whether additional methods or tools are required to support effective service prototyping [8]. While the collaborative "lifeline" between the two universities could have been strengthened through deeper data exchange and more structured interaction, the experience nevertheless demonstrated the value of purpose-driven international collaboration.

5 CONCLUSIONS

This paper presents a comparative and qualitative analysis of two thematically aligned educational projects focused on sustainable agricultural innovation. Rather than making broad claims regarding educational transformation or innovation impact, the findings demonstrate more specifically how differences in project framing, technological constraints, and stakeholder access shaped student learning experiences and design outcomes. Notably, the Aston University case encouraged broad conceptual exploration and service-oriented thinking, whereas in contrast, the Mälardalen University case supported focused technical development within a constrained XR environment. A key contribution of the study lies in identifying recurring challenges across both settings, particularly the difficulty students experienced when engaging with unfamiliar agricultural contexts and accessing relevant stakeholders for iterative feedback. In addition, both cases generated useful insights and concepts that could be of value to the company DeLaval, in relation to user-centred innovation and technology-led innovation. The study also suggests that thematic alignment can be an inspirational source for interaction and between different courses, providing a comparative reflection and exposure complementary design approaches. Given the limited empirical evidence, indications derived from the present cases should be interpreted cautiously due to the exploratory nature of the study, the limited cohort sizes, and the qualitative character of the analysis. In summary, clear agendas and focused objectives remain essential; yet openness to cross-border learning can significantly enrich student understanding and design outcomes when supported by a shared thematic focus and aligned pedagogical intent. Future work would benefit from more systematic longitudinal evaluation, comparative student reflections, stakeholder assessment metrics, and structured collaboration activities between institutions to strengthen the analytical basis for evaluating educational outcomes.

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