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(IJIREV)**www.gaexcellence.com/ijirev**INTEGRATING USABILITY TESTING IN HUMAN-
CENTERED INDUSTRIAL DESIGN EDUCATION**

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Abstract:

Human-Centered Design (HCD) is essential in Industrial Design education because students are expected to move beyond personal assumptions and incorporate user evidence into product development. However, the educational value of usability testing depends not only on gathering user feedback, but also on students' ability to interpret evidence, prioritise usability concerns, make evidence informed design decisions, and refine physical prototypes. This study examines how usability feedback can be interpreted and translated into iterative physical prototype refinements within Human-Centered Design education. Positioning HCD as the primary design paradigm and Experiential Learning Theory (ELT) as the explanatory lens, the study conceptualises usability testing as a cycle of concrete experience, reflective observation, abstract conceptualisation, and active experimentation through which students interpret user evidence and translate it into design action. The framework is illustrated through two student usability testing cases involving exercise equipment and a postural stability and balance support device for older users. The illustrative evaluations demonstrate how structured feedback informed prototype refinements related to ergonomic fit, dimensional suitability, structural stability, and task performance. The study contributes theoretically by conceptualising design interpretation as an interpretive link between user feedback and physical design action, and

pedagogically by proposing a structured feedback-to-refinement process through which students capture feedback, interpret evidence, prioritise usability problems, implement modifications, and re-evaluate prototypes.

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Keyword:

Design Decision-Making, Human-Centered Design, Iterative Prototyping, Product Refinement, Usability Testing, User Feedback



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Introduction

Contemporary product development requires designers to respond to increasingly diverse user needs, complex contexts of use, technological developments, and changing social expectations. Within this environment, Human-Centered Design (HCD) provides an important approach by positioning users' experiences, needs, capabilities, and behaviours at the centre of design development rather than relying primarily on designers' assumptions. Contemporary HCD emphasises sustained user involvement, inquiry, iterative prototyping, and evaluation as interconnected activities throughout the design process. Usability testing is particularly relevant because it provides opportunities to identify difficulties and unexpected behaviours through users' interaction with design prototypes (Fleury & Chaniaud, 2023; Gorkovenko et al., 2023).

The integration of HCD is particularly important within Industrial Design education. Industrial Design students are expected to investigate user needs, generate concepts, develop prototypes, evaluate design solutions, and make informed decisions throughout the product development process. However, students are still developing their ability to interpret user requirements and translate evidence into appropriate design responses. Previous research has demonstrated the value of structured human-centered processes, prototyping, user–designer interaction, and reflection in developing students' design capabilities (Soyupak, 2021; Yevenes et al., 2023). Recent research has similarly emphasised experiential and research-based approaches in HCD education, encouraging students to engage directly with users and iterative design activities rather than treating design as a predominantly linear process (Novoa Munoz & Parulekar Prasad Hari, 2025).

Despite these developments, a significant issue remains concerning what happens after usability testing has been conducted. Identifying a usability problem does not necessarily mean that a student understands its cause, recognises its significance, or knows how to translate it into an appropriate design modification. User feedback may contain functional, ergonomic, aesthetic, behavioural, or contextual observations, and students must determine which concerns are relevant to the design problem and which should be prioritised. Consequently, the educational value of usability testing may depend less on the amount of feedback collected than on students' capacity to interpret evidence and use it to support defensible design decisions.

This issue is particularly relevant because previous literature has often examined HCD, usability, product experience, reflective learning, and prototyping as valuable practices but has provided comparatively limited explanation of the process connecting user feedback with student design action. The existing literature indicates that UX research can reveal useful design requirements, yet the integration of these findings into concrete design processes remains insufficiently articulated (Berni et al., 2023). This distinction further supports the need to examine Design Interpretation as an explicit process through which students make sense of usability evidence before determining an appropriate design response. This creates an opportunity to conceptualise usability testing as more than a final validation procedure. Instead, it can be positioned as an evidence-generating activity through which students learn to observe users, interpret evidence, make design decisions, refine prototypes, and evaluate the consequences of those decisions.

However, existing research provides comparatively limited explanation of how industrial design students interpret usability evidence after testing and translate that evidence into specific physical design actions. Much of the existing discussion emphasises user involvement, feedback collection, usability evaluation, or learning outcomes, while the interpretive process linking user feedback to design modification remains less explicitly articulated. It is necessary to describe how students identify the significance of usability problems, determine their possible reasons, prioritise competing issues, and translate interpreted evidence into concrete prototype refinements. Addressing this gap is important because usability testing in design education should not be understood solely as a mechanism for collecting feedback, but also as a learning process through which students develop evidence-based design reasoning and iterative design action.

Accordingly, this study examines how usability feedback can be interpreted and translated into iterative physical prototype refinements within Human-Centered Design education. Specifically, the study aims to: (1) clarify the relationship between product experience and usability evidence; (2) explain the role of design interpretation in transforming user feedback into design decisions; (3) conceptualize the relationship between design decisions and subsequent prototype refinement; and (4) develop an integrated framework connecting usability testing, experiential learning, design interpretation, and iterative product refinement in Industrial Design education. These objectives are reflected in the proposed framework, which positions usability testing as an iterative evidence-generating activity within the HCD process, while Design Interpretation provides the analytical link between user feedback and subsequent design action.

Literature Review

Table 1. Selected Studies Related To Usability Testing, HCD Education, Prototype Evaluation And Iterative Product Development

Author(s)	Year	Study / Title	Context & Method	Key findings relevant to your study
Karahanoğlu	2022	<i>Act like a user, work like a teacher: evaluation of experience design works through peer-testing</i>	Practice-based design education; peer-testing of students' experience-design work	Peer-testing enabled students to experience their designs from a user perspective and supported learning about user testing and design evaluation. The study is particularly relevant to the educational role of testing rather than treating evaluation solely as a final assessment.
Yevenes et al.	2023	<i>On the cusp of a wave: Experiences in designing a usability test experiment in an Industrial Design PhD research project involving vulnerable participants during the COVID-19 pandemic</i>	Industrial Design research; usability-testing experiment involving vulnerable users; case-based methodological reflection	Demonstrated the complexity of designing and adapting usability-testing protocols in real-world Industrial Design research. The study highlights participant, contextual and methodological considerations that can affect the quality of usability evidence
Fleury & Chaniaud	2023	<i>Multi-user centered design: Acceptance, user experience, user research and user testing</i>	Conceptual/review-oriented examination of user-centred design, user research and testing	Argues for a broader understanding of user-centred design in which user research and testing are integrated into an evolving design process rather than

				treated as isolated activities. This supports the iterative orientation of your study.
Gorkovenko et al.	2023	<i>Data-enhanced design: Engaging designers in exploratory sensemaking with multimodal data</i>	Design research; designers' interpretation and sensemaking of user-related data	Shows that design data require interpretation and sensemaking before they can meaningfully influence design activity. This is relevant to your focus on the transition from user evidence to design decisions.
Geszten et al.	2024	<i>Team usability testing: Development and validation of a groupware usability evaluation method</i>	Development and validation study; structured team usability testing	Demonstrates the value of structured usability-testing procedures and provides evidence that usability evaluation can be systematically organised rather than conducted informally.
Griffith et al.	2024	<i>An iterative approach to usability evaluation: A workplace wellness mobile application example</i>	Three rounds of usability testing using observation, interviews, task-based testing and surveys	Each testing round identified usability issues that informed subsequent refinement. Particularly relevant to your proposed test → feedback → refinement → retest structure.
Sanders et al.	2024	Study of human-centered approaches among design/technology students	Educational research examining students' design priorities and HCD practices	Findings indicate that students do not necessarily prioritise human-centered approaches simply because these methods are included in

					education; some prioritise technical, aesthetic or novelty-related considerations. These supports investigating how students respond to user evidence.
Novoa Munoz & Parulekar Prasad Hari	2025	<i>Expansive learning as a system design method to learn human-centered design in a multi-disciplinary industrial design and built environment subject</i>	Practice-based HCD education; multidisciplinary Industrial Design/built-environment subject		Highlights the value of experiential learning, inquiry, engagement with users and continuous prototyping in developing HCD capabilities. It supports treating HCD as an iterative learning process rather than a linear design procedure.
Codner & Lauff	2025	<i>Understanding prototype testing: How student designers structure sessions and ask questions with stakeholders</i>	Undergraduate product design and innovation course; 62 students; stakeholder prototype-testing sessions		Directly relevant to student product development: prototype testing can be structured to generate needs, requirements and learning for subsequent iterations. It also demonstrates that testing practices themselves influence the quality of information obtained from stakeholders.

Product Experience and Human-Centered Design

Human-Centered Design positions people's experiences, capabilities, needs, and contexts as fundamental considerations in the development of products and services. Within Industrial Design, this orientation extends beyond functional performance to consider how products are perceived, interpreted, used, and experienced in actual contexts. Product experience therefore encompasses perceptual, cognitive, emotional, behavioural, and contextual dimensions that

may emerge during interaction between users and products. Recent research has highlighted the multidimensional nature of product experience and the relevance of users' perceptual, cognitive, and affective responses in understanding product interaction (Berni et al., 2023; Pizzolante et al., 2024).

Usability represents an important but distinct component of product experience. While usability concerns the extent to which users can achieve intended goals effectively, efficiently, and satisfactorily within a specified context of use, product experience represents a broader construct that includes the experiential consequences of interacting with a product. A product may therefore satisfy technical or functional requirements while still generating uncertainty, discomfort, awkward interaction, or dissatisfaction. This distinction establishes the importance of usability testing as a means of examining the relationship between intended product characteristics and actual user experience.

Within HCD, usability testing should consequently be integrated throughout product development rather than positioned solely as an end-stage evaluation. Fleury and Chaniaud (2023) emphasise the need to integrate user research and user testing into broader user-centered processes, particularly when products involve complex users and contexts. Similarly, UX research can reveal design requirements that may not be apparent through conventional evaluation (Berni et al., 2023). The significance of usability testing therefore lies not simply in determining whether a product is usable but in generating evidence that can influence subsequent design activities.

This perspective is particularly important in Industrial Design education. Students commonly engage in research, ideation, prototyping, testing, and refinement, but the transition between these activities may not always be explicit. Exposure to HCD methods does not automatically guarantee that students will consistently prioritise user evidence over technical, aesthetic, or novelty related considerations. The educational challenge is therefore to help students understand how user evidence can become actionable design knowledge. Usability testing provides an opportunity to make this relationship visible because students can observe actual interactions, compare these observations with their design assumptions, and consider how the product should be modified.

Accordingly, the present study conceptualises product experience as the experiential foundation of the proposed framework. User interaction generates observable and reported evidence, usability testing captures this evidence, and students subsequently interpret the findings before deciding how the product should be refined. This establishes the first conceptual relationship in the study:

Product Experience → Usability Evidence → Design Interpretation → Design Action.

Usability Testing as Design Knowledge Generation

Usability testing produces evidence through users' interactions with prototypes. Such evidence may include observed difficulties, behavioural patterns, verbal comments, preferences, ergonomic concerns, safety issues, and contextual problems. However, usability evidence should not be regarded as equivalent to a design decision. Feedback provides information about an experience, whereas design decision-making requires the designer to interpret the information, determine its relevance, prioritise the problem, and evaluate possible responses.

This distinction is particularly significant in student design projects. Novice designers may interpret identical user comments differently depending on their prior knowledge, assumptions, understanding of the design brief, technical capabilities, and project constraints. Consequently, the quantity of feedback collected is not necessarily an appropriate indicator of the extent to which HCD has influenced the design process. A more meaningful consideration is whether students can transform user evidence into defensible design reasoning and observable prototype changes.

The distinction between feedback and design response also addresses an issue identified in UX research. Although UX research can reveal useful design requirements, the mechanisms through which these findings influence concrete design processes remain insufficiently articulated (Berni et al., 2023). Within the present framework, this problem is addressed by introducing Design Interpretation as an explicit stage between user feedback and design decision making.

Design interpretation involves examining what users experienced, why the problem may have occurred, how significant the issue is, and whether it should be addressed in relation to other design requirements. For example, when a user experiences difficulties operating a product, a student must determine whether the problem results from the product's dimensions, form, affordance, interaction mechanism, sequence, material, or instructions. The resulting design response may involve modifying the product, simplifying an interaction, repositioning a component, changing dimensions, or deciding not to implement the feedback where it conflicts with another critical requirement.

Usability testing can therefore be conceptualised as a form of design knowledge generation. The process moves from user interaction to evidence, from evidence to interpretation, and from interpretation to design action. The resulting product modification then provides an opportunity for subsequent testing. This creates an iterative relationship in which each testing cycle contributes to the development of both the product and the student's design reasoning.

Experiential Learning Theory as the Primary Theoretical Lens

Experiential Learning Theory (ELT), especially Kolb's experiential learning cycle, offers a helpful way to understand how students learn through usability testing. According to ELT, learning happens in a cycle that includes having a hands-on experience, reflecting on it, forming new ideas, and then trying those ideas out. This approach fits well with usability testing because it lets students see firsthand how users interact with a product. These real interactions can either support or challenge the students' original ideas, helping them learn and improve based on what they observe.

In the proposed framework, usability testing serves as the concrete experience stage because students watch users interact directly with their physical prototypes, gaining real evidence of how the product is actually used. Reflective observation happens when students review how users behave, listen to their feedback, notice any difficulties, preferences, and performance, and compare these insights with their initial design ideas. During the design conceptualization phase, students analyze the usability issues they found, think about possible reasons behind them, and develop new design requirements or alternative solutions. Active experimentation takes place when students apply these design changes to their prototypes and then test the improved product again through further usability evaluations. So, the ELT cycle looks like this:

Experience → Reflection → Conceptualization → Experimentation

This process shows how usability testing is more than just a way to evaluate a product—it's a powerful learning tool. It helps students turn direct user experiences into thoughtful reflection, deeper understanding, and meaningful design improvements.

Experiential Learning Theory (ELT) explains how usability testing serves as a valuable learning experience rather than merely a product evaluation tool. By observing users, students gather insights that challenge designer-centric assumptions. Through reflection, they can re-evaluate their initial choices, while conceptualization helps them build new design requirements and alternative explanations. Finally, modifying prototypes enables these new concepts to be tested and refined through continued interaction.

This study utilizes Kolb's Experiential Learning Theory (ELT) to demonstrate how usability testing acts as an active learning experience rather than a basic product evaluation method. By navigating the four stages of the ELT cycle, students learn to question their assumptions about design by observing, analyzing, and translating direct user feedback into practical design steps. By combining this educational framework with the Human-Centered Design (HCD) approach, the study creates a balanced focus that supports both student learning and effective design outcomes.

Methodology

Research Design

The study does not generate a new statistical dataset or empirically test causal relationships among students, users, or prototypes. Instead, it develops an explanatory framework through critical engagement with established theoretical perspectives and illustrative usability testing case studies concerning HCD, usability testing, product experience, iterative prototyping, and Industrial Design education. The approach is therefore conceptual in its research design while remaining usability testing informed through the findings and observations reported in the selected literature. The distinction is important because the study seeks to explain an under-specified relationship rather than claim validation of the proposed framework based on the illustrative usability-testing cases.

For illustrative application, the framework is examined against two student usability testing artefacts involving physical product prototypes. Product A, an exercise equipment prototype for elderly users, involved three respondents evaluating five usability criteria. Product B, a postural stability and balance support device, involved three older adult respondents comparing two low-fidelity mock-up iterations. These cases are used as illustrative evidence to demonstrate how usability observations can be organised into design interpretation, design decision making, and subsequent prototype refinement. They are not treated as a representative sample and are not used to establish statistical generalisation or causal relationships.

HCD is adopted as the main design orientation, while ELT provides the primary explanatory lens for understanding the transformation of user testing experiences into learning and design action. The central proposition is that usability testing functions as iterative evidence generating activity through which product experience produces usability evidence, students interpret the evidence, the interpreted findings inform design decisions and the resulting design

responses are incorporated into subsequent prototype refinement. The revised prototype can subsequently undergo another usability evaluation, thereby creating an iterative HCD cycle.

The uploaded student usability testing cases are incorporated as an illustrative application of the framework. The artefact concerns a walker mock-up for children with Down syndrome and documents mock-up development, usability testing statements, parent feedback, posture analysis, and conclusions concerning safety, proportion, ergonomics, material, and aesthetics. The document reports concerns such as excessive product height and insufficient belt security while identifying positive aspects such as handle placement and lightweight material. These observations are used solely to demonstrate how the proposed conceptual framework can organise usability evidence into interpretation and design refinement.

Analysis and Synthesis

First, HCD literature was examined to establish the importance of user involvement, inquiry, participation, prototyping, and iterative evaluation. Second, product experience and usability literature were compared to distinguish the broader experiential dimensions of product interaction from specific usability evidence relating to effective, efficient, and satisfactory use. Third, Industrial Design education literature was examined to identify the learning requirements associated with reflection, user interaction, prototype development, feedback interpretation, and evidence-based design reasoning.

Finally, ELT was examined to determine how experiential learning could explain the transition from direct user testing experience to reflective analysis, conceptual understanding, and subsequent prototype experimentation. The synthesis indicated that HCD and ELT could be integrated without assigning them identical theoretical functions. HCD establishes the user-centered design orientation, while ELT explains the learning process through which students may transform usability-testing experiences into design knowledge.

Framework

The conceptual framework was developed by organising the synthesised constructs into an iterative structure directly aligned with the research objectives. Product Experience was positioned as the starting point because usability concerns emerge through interactions between users and products. Usability testing then generates Usability Evidence/User Feedback, which captures observed behaviour, difficulties, expectations, preferences, and contextual issues. The synthesis resulted in the following conceptual sequence.

Product Experience → Usability Evidence/User Feedback → Design Interpretation → Design Decision-Making → Product Refinement → Subsequent Usability Evaluation

The next construct, design interpretation, represents the cognitive and analytical process through which students examine the evidence. Students identify the nature and potential effects of usability problems, assess their relevance to the design brief, and prioritise issues in relation to competing design requirements. The interpreted evidence then informs design decision-making, through which students determine appropriate responses concerning form, dimensions, affordances, interaction mechanisms, materials, instructions, or other product characteristics. The design decisions inform product refinement, which provides a tangible outcome that can be compared with the previous prototype. The revised product can then be

subjected to Subsequent Usability Evaluation, allowing students to determine whether the intervention addressed the identified problem and to identify additional issues. The process consequently forms an iterative cycle rather than a linear sequence.

Usability Testing Findings: Exercise Equipment for Elderly Users (Product A)

The evaluation of the exercise equipment prototype (1:5 scale and 1:1 full-scale mock-up standing at 82 cm) involved three respondents assessing usability across five key criteria

Table 2: Usability Testing Results for Exercise Equipment for Elderly Users

No.	Evaluation Question / Criteria	R1	R2	R3	Overall Agreement Pattern
Q1	Comfort & Ease of Use: Does the design make it easy for elderly users to perform exercises comfortably?	Agree	Agree	Agree	Consensus (Agree)
Q2	Ergonomics & Grip: Is the handle grip comfortable and easy to hold during exercise?	Agree	Agree	Agree	Consensus (Agree)
Q3	Stability & Safety: Is the equipment stable and safe to use during movement/balance exercises?	Agree	Agree	Agree	Consensus (Agree)
Q4	Functional Support: Does it help improve mobility and physical activity for elderly users?	Agree	Agree	Agree	Consensus (Agree)
Q5	Dimensional Suitability: Is the size and height suitable for elderly users?	Disagree	Disagree	Disagree	Consensus (Disagree)

Source: Adapted from Student Usability Evaluation Project Data (Muhammad Syafiq, 2026)

Qualitative Feedback and Observational Analysis (Product A)

The qualitative feedback and posture analysis revealed key user observations across four core design dimensions:

- **Practicality & Functionality:** Respondents noted that the prototype is easy to operate and effective in supporting basic exercises such as hand squishy, knee extension, standing leg curl, toe stand, and cycling steps.
- **Ergonomics & Posture:** The anti-slip handle and foot-step features provided comfortable grip and posture support. However, Respondent 3 highlighted that handle grip ergonomics could be further refined.
- **Proportion & Height (Critical Issue):** All three respondents unanimously disagreed regarding the adequacy of the height and sizing (82 cm height), emphasizing that the fixed dimensions lack adjustability for varied elderly body proportions.
- **Aesthetics:** Feedback ranged from "simple and clean appearance" to "not visually attractive," suggesting a need for visual refinement to increase user engagement

The case study of Product A, which focuses on exercise equipment for older adults, clearly demonstrates the iterative Human-Centered Design process. It begins with an initial product experience where elderly users test a 1:1 scale (82 cm) prototype through exercises like cycling and knee extensions. This interaction generates structured feedback: users universally praised the ease of use and grip ergonomics but unanimously disliked the fixed height and visual appeal.

These findings directed the subsequent design decisions, prompting the replacement of fixed joints with adjustable telescoping mechanisms and the updating of visual finishes. This guidance led to the physical refinement of the rigid prototype into a height-adjustable system. Finally, this updated model is scheduled for further usability testing to empirically confirm whether these structural adjustments successfully enhance user safety, ergonomic comfort, and overall functional satisfaction.

MOCK-UP USABILITY TESTING		TITLE : AN INTERACTION AND PRODUCT DESIGN OF EXERCISE EQUIPMENT FOR ELDERLY USERS
PERSONA (respondent)		EVALUATION on gathering user feedback by taking a design or prototype into the public domain and asking passersby for their thoughts.
	Analysis on Testing (Participant controlling button menu using freehand gestures)	Analysis on Testing (Hand Posture)
Name: Danish Age: 19 Occupation: Student Picture		
Feedback	Practical : Easy to use Ergonomics : Comfortable grip Propotion : Suitable height and width Aesthetic : Design simple and not attractive	

Figure 1. Evaluation Focused On Gathering User Feedback By Bringing A Physical Prototype

Source: Adapted from Student Usability Evaluation Project Data (Muhammad Syafiq, 2026)

MOCK-UP USABILITY TESTING		TITLE : AN INTERACTION AND PRODUCT DESIGN OF EXERCISE EQUIPMENT FOR ELDERLY USERS
PERSONA (respondent)		EVALUATION on gathering user feedback by taking a design or prototype into the public domain and asking passersby for their thoughts.
	Analysis on Testing (Participant controlling button menu using freehand gestures)	Analysis on Testing (Hand&foot Posture)
Name: Syazwan Age: 20 Occupation: Student Picture		
Feedback	Practical : Convenient to operate Ergonomics : Good hand support Propotion : Appropriate dimensions Aesthetic : Clean appearance	

Figure 2. Posture Analysis: Highlights hand posture, showing how the user grips the handle structure during interaction

Source: Adapted from Student Usability Evaluation Project Data (Muhammad Syafiq, 2026)

Usability Testing Findings: Subsequent Usability Evaluation: Postural Stability & Balance Support Device (Product B)

The second evaluation examined two iterative physical mock-ups (Mock-up 1 vs. Mock-up 2) designed to enhance postural stability and standing balance support for older adults.

Table 3: Comparative Persona And Feedback Analysis Across Low-Fidelity Mock-Ups Iteration

Respondent	Age & Size	Mock-up Feedback Analysis	1 & Feedback Analysis	2 & Feedback Analysis	Preferred Design
Respondent 1	Age: 75 Shoe Size: 7	Practicality: Easy to use. Material: Good Posture Observation: Foot posture appeared slightly unstable with uneven weight distribution.	Practicality: Easy to install Ergonomics: Highly comfortable Posture Observation: More stable foot posture, superior weight distribution, secure Velcro attachment.		Mock-up 2
Respondent 2	Age: 65 Shoe Size: 10	Practicality: Easy to move Posture Observation: Slightly unstable, minor adjustments needed for balance	Functionality: Wide sole provided greater stability Ergonomics: High comfort Posture Observation: Balanced, secure placement.		Mock-up 2
Respondent 3	Age: 60 Shoe Size: 5	Practicality: Functional barefoot/with shoes Posture Observation: Minor instability while standing	Functionality: Enhanced body posture stability Critique: Wide base made walking slightly cumbersome		Mock-up 2

Source: Adapted from Student Usability Evaluation Project Data (Noor Azhamin Izham, 2026)

The comparison between Mock-up 1 and Mock-up 2 for Product B, a device supporting balance and postural stability—highlights the iterative nature of the Human-Centered Design framework. The process commenced with an initial product experience phase, during which older adults aged 60 to 75 interacted with physical mock-ups intended to aid walking and standing stability. This user engagement produced valuable feedback: posture evaluations showed that Mock-up 1 caused minor, ongoing foot instability and uneven weight distribution. On the other hand, while Mock-up 2 delivered better balance support, participants reported that its wide base made walking somewhat difficult.

Upon interpreting these findings, the student designer recognized that adding a broader sole and secure Velcro straps successfully fixed foot placement issues and improved static balance, but created a trade-off by hindering smooth, natural strides during movement. This critical insight drove an important design choice: to adjust the base dimensions so they balance dynamic walking clearance with structural support, while preserving the effective Velcro fastening system. Consequently, these insights led to a recommended update to optimize the foot sole boundaries in the next prototype. Additional usability testing will be needed to verify whether these revised dimensions successfully achieve a balance between walking mobility and standing stability for older users.

USABILITY TESTING

TITLE : To design Postural Stability and Standing Balance Support Items for Ader AdultsAdults

PERSONA (respondent)	MOCK UP (Analysis on Testing)
Name : Age : Occupation : Size : 7	
Feedback	Practical : Easy to use Propation : Refine the size Material : Good Function : Easy to instal Ergonomics : Need to improve in terms of design

Figure 3. Observational & Posture Analysis: Observe Task Performance, Such As Hand Grips, Foot Placement, Balance Stability, And Gesture Interactions, To Identify Physical Friction Or Ergonomic Issues.

Source: Adapted from Student Usability Evaluation Project Data (Noor Azhamin Izham, 2026)

MOCK-UP 2 USABILITY TESTING

TITLE : To design Postural Stability and Standing Balance Support Items for Ader AdultsAdults

PERSONA (respondent)	MOCK UP (Analysis on Testing)
Name : Age : Occupation : Size : 7	
Feedback	Practical : Easy to use Propation : Refine the size to easy to move Material : Nice Function : The feet will be more stable because they are supported by Velcro. Ergonomics : Comfortable

Figure 4. User Personas & Participants: Observing Real Users As They Interact With A Physical Low-Fidelity Mock-Up

Source: Adapted from Student Usability Evaluation Project Data (Noor Azhamin Izham, 2026)

Discussion and Conclusion

The results and conceptual synthesis of this study suggest that the educational benefit of usability testing in industrial design goes beyond the gathering of user feedback. The educational value is in helping students make sense of the evidence from usability testing, and in helping them to turn the insights into tangible changes to physical prototypes. This research formulates an ongoing connection among product experience, user feedback, design interpretation, design decision-making, prototype enhancement, and ensuing usability assessment. This sequence tackles a recognized deficiency in design education research regarding students' interpretation of evidence obtained from usability testing and their subsequent application of that evidence to modify physical prototypes.

The proposed framework follows current Human-Centered Design (HCD) principles, where inquiry, user involvement, prototyping and assessment are interconnected and iterative. Existing research has examined the integration of user testing as a component of broader product-development processes and of experiential learning contexts. The present framework builds on these perspectives by contextualizing Design interpretation is a unique and vital stage between user input and design action. This distinction is important because user feedback doesn't always lead to a specific design solution. Instead, student designers need to examine the data that is available, determine root or underlying causes, think about the constraints of the project, and rank the relevant issues before deciding what design changes are appropriate. Design Interpretation therefore functions as a critical cognitive bridge through which user-generated evidence is transformed into actionable design knowledge.

Experiential Learning Theory (ELT) provides the underlying explanatory mechanism for this framework. Within the proposed model, Concrete Experience occurs when students test physical prototypes with real users. Reflective Observation takes place as students examine user behaviour, performance issues, and verbal comments arising from the testing process. Abstract Conceptualization occurs when students identify underlying ergonomic or functional causes and formulate corresponding design requirements. Active Experimentation is realised when students modify the prototype and subsequently conduct further usability testing to evaluate the effects of those modifications. This integration of HCD and ELT clarifies how usability testing can function simultaneously as a product evaluation method and an evidence-based learning mechanism.

Implications for Industrial Design Education

The proposed framework also has implications for the assessment and facilitation of usability-testing activities in Industrial Design education. Conventional studio assessment may place greater emphasis on the quality of the final design outcome, whereas the proposed approach places greater visibility on the reasoning connecting user evidence to design changes. A feedback-to-refinement record can provide a structured means of capturing this reasoning by documenting the progression from user observation and feedback, through interpretation and prioritisation, to design modification and re-evaluation.

This approach may also support educators in assessing aspects of design reasoning that are not readily observable in the final prototype. For example, two students may produce similar physical modifications while arriving at those decisions through substantially different interpretations of user evidence. Recording the evidence, interpretation, rationale, and

subsequent testing outcome provides a means of making these otherwise implicit processes more explicit and assessable. Thus, the framework positions usability testing as both a design-development activity and a pedagogical mechanism for developing students' capacity to reason from evidence.

Limitations and Future Research

As a conceptual synthesis, this study does not provide empirical evidence demonstrating the effectiveness of the proposed framework in actual Industrial Design learning environments. The relationships proposed between user feedback, Design Interpretation, design decision-making, prototype refinement, and learning therefore require empirical examination. Future research should investigate the framework across multiple Industrial Design student projects and successive prototype-development cycles to examine how these relationships operate in authentic studio contexts.

Longitudinal classroom studies could investigate how students' abilities to interpret and prioritise usability evidence develop across repeated testing sessions. Video Protocol Analysis could further examine the moment-to-moment relationship between user behaviour, student reflection, interpretation, and subsequent design decision-making. Comparative research could also examine whether structured feedback-to-refinement tools support evidence-based design reasoning differently from conventional studio critique approaches. In addition, future studies should operationalise constructs such as interpretation quality, usability-problem prioritisation, design-decision justification, and prototype improvement through validated assessment rubrics and mixed-method research designs.

In conclusion, usability testing can be understood within Industrial Design education as an iterative mechanism through which students learn from users, question design assumptions, develop evidence-based reasoning, and improve physical products. The proposed framework conceptualizes usability testing as a cyclical process in which students capture user feedback, interpret user experiences, identify and priorities usability problems, formulate design responses, implement prototype modifications, and re-evaluate the revised product. The central contribution of the framework is the explicit recognition of Design Interpretation as the critical link between user evidence and design action. By integrating this interpretive stage with HCD and ELT, the framework provides a conceptual explanation of how usability testing can simultaneously support product evaluation and experiential learning. From a pedagogical perspective, the proposed feedback-to-refinement process can be incorporated into Industrial Design studio courses through structured tracking records that document the relationship between user evidence, interpretation, design rationale, physical prototype modification, and re-testing outcomes. Such an approach has the potential to make students' evidence-based design reasoning more explicit, traceable, and assessable, while positioning usability testing as an integral component of iterative learning rather than merely a final product-validation activity.

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Declaration on the Use of Artificial Intelligence (AI)	“The author(s) declare that generative AI or AI-assisted technologies were used during the preparation of this manuscript. The following tool(s) were used: AI tool (quillbot,gemini,chatgpt). The tool(s) were used for language editing and grammar improvement. All AI-assisted content was reviewed and verified by the author(s), who take full responsibility for the accuracy, originality, integrity, and final content of the manuscript.”

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