

Industry-Inspired Learning Behaviors in Furniture Design Education for Non-Design Background Students

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ABSTRACT

Vocational higher education increasingly enrolls students from diverse educational backgrounds, creating challenges in developing industry-ready furniture design competence. This study examines how industry-inspired learning behaviors support competence development among students without prior design-related education. Using an applied case-based explanatory approach, institutional records of 202 students enrolled between 2018 and 2022 were analyzed, with 77.72% originating from non-design-related high schools. Learning activities incorporated manufacturing-oriented practices, including SOP-based design processes, constraint-driven tasks, iterative revisions, continuous feedback, and full-scale 1:1 furniture prototyping. Competence was validated through professional certification, internship performance, prototype documentation, and recruitment outcomes. The findings show that students successfully produced production-ready, material-efficient furniture designs and demonstrated satisfactory workplace performance. Recruitment before graduation further confirmed employer recognition of their competencies. The study concludes that structured, industry-inspired learning effectively develops transferable furniture design competence and supports workforce readiness in vocational higher education.

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Introduction

Vocational and applied higher education programs are designed to equip students with competencies that are directly aligned with industry needs and workplace performance. In response to industrial demands for innovation and product development capability, many vocational programs have incorporated design-related courses into their curricula. However, a persistent challenge arises from the heterogeneity of students' prior educational backgrounds. Some students enter furniture design-related programs with previous design-related preparation, while others come from high school backgrounds that do not provide formal exposure to design, technical drawing, product development, or furniture construction. This condition creates a pedagogical challenge because students are expected to perform complex design tasks that often implicitly assume prior design literacy and experience. It also reflects a broader issue in vocational education, where learners' prior experiences strongly influence the effectiveness of competence acquisition (Billett, 2011; OECD, 2020; Winch, 2015).

Within vocational education, furniture design should be understood as an applied professional competence rather than a purely artistic or expressive activity. While aesthetic considerations remain relevant, effective furniture design requires a strong emphasis on manufacturability, material behavior, structural logic, and production processes. Design decisions directly affect material efficiency, machining complexity, assembly time, and product durability. Consequently, furniture design competence in vocational contexts is closely linked to feasibility, production readiness, and alignment with industrial constraints. This perspective is consistent with product development and engineering design literature, which emphasizes that successful design outcomes depend on systematic processes, technical constraints, and integration with manufacturing considerations (Pahl et al., 2007; Ulrich and Eppinger, 2016; Ulrich and Eppinger, 2020). Such characteristics make furniture design particularly compatible with the objectives of vocational education, which prioritize employability and applied competence.

Importantly, contemporary design education research increasingly rejects the assumption that design ability is innate. Instead, design competence is viewed as a trainable capability that can be systematically developed through structured learning, guided practice, and iterative refinement (Cross, 2023; Lawson, 2020). This view supports the inclusion of furniture design training for students without formal design backgrounds, provided that learning activities are aligned with vocational and industrial logic. However, much of the existing design education literature continues to focus on students from formal design disciplines, emphasizing studio-based learning, creative exploration, and aesthetic development (Cross, 2011; Lawson, 2006; Lawson and Dorst, 2009). As a

result, limited attention has been given to how design competence is acquired by non-design students in vocational settings, particularly in applied fields such as furniture design.

From a vocational pedagogy perspective, competence acquisition is strongly shaped by learning behavior and training structure. Unlike academic learning environments that prioritize conceptual mastery, vocational education emphasizes procedural accuracy, task repetition, and continuous performance improvement. Empirical studies consistently show that learners' engagement with structured procedures, repeated task execution, and feedback utilization plays a decisive role in competence development (Billett, 2019; Sudira, 2022). These learning behaviors are especially critical for novice learners, as they reduce ambiguity, support skill internalization, and facilitate progressive improvement.

Manufacturing and human resource development literature further reinforces this perspective. Competency-based training models emphasize clearly defined performance standards and evaluate learning outcomes based on demonstrated capability rather than prior educational background (Sudira et al., 2021; Rahmaningtyas et al., 2023). On-the-job training principles highlight learning-by-doing under supervision, while standardized work practices provide consistent procedures that stabilize performance and support continuous improvement Liker (2021). In addition, deliberate practice theory emphasizes focused repetition, incremental difficulty, and timely feedback as key mechanisms for developing complex skills, including in vocational and technical education contexts (Ericsson & Pool, 2016; Salas et al., 2012; Salas et al., 2022). Although learning factories and industry-simulated environments have been shown to enhance vocational competence (Abele et al., 2017; Berglund et al., 2020), these approaches have rarely been examined in relation to design competence development among non-design-background students.

Taken together, the literature suggests that furniture design competence in vocational education is not solely dependent on prior design background, but can be developed when learners are guided through structured, industry-aligned learning behaviors embedded within instructional practice. Nevertheless, there remains a lack of applied empirical studies explaining how such competence is developed among students with heterogeneous educational backgrounds and how the resulting competence is validated through authentic vocational evidence. Existing research has tended to emphasize instructional models or classroom-based learning outcomes, while providing limited insight into the mechanisms through which design competence emerges, is transferred into workplace settings, and gains recognition from industry stakeholders.

Therefore, this study aims to explain how industry-inspired learning behaviors, specifically

structured procedural adherence, iterative task engagement, and systematic feedback utilization, facilitate the acquisition of furniture design competence characterized by feasibility, production readiness, and material efficiency among students without prior design-related educational preparation in vocational higher education. By focusing on professional certification, full-scale prototype development, industry internship performance, and recruitment tracking, this study positions competence validation as an applied and externally recognized process rather than as an internal classroom assessment alone.

Method

This study adopts an applied vocational education research design using a case-based explanatory approach. The research explains how industry-oriented learning processes support furniture design competence development among students without formal design backgrounds. Competence is validated through external and authentic indicators rather than classroom-based testing, consistent with competency-based vocational education principles (Billett, 2019; Winch, 2020). This approach was selected because the study focuses not only on whether students achieved competence, but also on how structured, industry-aligned learning processes supported the development and validation of that competence.

The study was conducted in a furniture design-related program at an applied vocational higher education institution. Aggregated institutional records from entry years 2018–2022 identified 202 students enrolled in the program. Of these students, 157 students, or 77.72%, came from non-design-related high school backgrounds, while 45 students, or 22.28%, came from design-related high school backgrounds. In this study, design-related high school background refers to prior secondary education that provided formal exposure to design-relevant knowledge and skills, such as interior design, furniture design and technology, visual communication design, technical drawing, drafting, or other closely related creative and technical design fields. Students from non-design-related high school backgrounds were therefore understood as students who entered the program without formal design-related preparation at the secondary education level. This classification was used to describe students' prior educational preparation, not to claim that students had no informal design interest, creativity, or learning potential.

The program consists of four semesters of campus-based learning followed by two semesters, or one year, of full-time industry internship in furniture manufacturing companies. Before graduation, students are required to complete a final project involving the development of a full-

scale 1:1 furniture prototype. These learning stages represent an integrated vocational pathway in which campus-based learning, industry exposure, and authentic product realization are connected to support competence development.

The learning intervention was implemented through a competency-based curriculum developed using the DACUM framework. In this study, DACUM was operationalized by translating industry-defined furniture design duties into curriculum activities, student tasks, and performance evidence. Learning activities included theoretical instruction, computer-based design practice, manual drawing, technical detailing, material specification, iterative design revision, and full-scale prototyping. The design process followed industry-inspired principles such as SOP-based stages, constraint-driven tasks, continuous feedback, and repeated refinement, reflecting standard manufacturing practices Liker (2021). Continuous instructor feedback supported deliberate practice and skill development Ericsson and Pool (2016). DACUM operationalization in industry-inspired furniture design learning presented in Table 1.

Table 1. DACUM operationalization in industry-inspired furniture design learning

<i>Competency-aligned task or validation area</i>	<i>Curriculum activity</i>	<i>Student output/evidence</i>
Establishing furniture design concepts	Design brief analysis, information gathering, concept exploration, and design rationale development	Concept sheet, preliminary sketches, and design rationale
Preparing furniture design documentation	Manual drawing, CAD-based drawing, technical detailing, and material specification	Working drawings, technical details, and material specification
Designing furniture products under production constraints	SOP-based design stages, manufacturability review, material consideration, and iterative design revision	Revised design based on feasibility, structure, material use, and production readiness.
Developing furniture samples or prototypes	Full-scale 1:1 prototype planning, construction detailing, material preparation, and production execution	Full-scale furniture prototype and prototype documentation
Estimating material and production costs	Bill of materials preparation, component listing, and basic production cost estimation	Material list, component list, and estimated production cost
Validating workplace competence	One-year industry internship and documented workplace assessment	Internship report, company supervisor assessment, and internal lecturer assessment

Furniture design competence was confirmed using triangulated external evidence rather than numerical test scores, consistent with vocational competency assessment principles (Billett, 2019; Winch, 2020). Evidence included:

- a. successful completion of a national professional competency certification administered by an authorized external body Sudira (2022);
- b. satisfactory performance during one-year full-time industry internship (OJT), demonstrating workplace application of design competence (Billett, 2019; Salas et al., 2022);
- c. development of a full-scale (1:1) furniture prototype as a graduation requirement, integrating design, material selection, and production execution; and
- d. early recruitment prior to graduation, indicating employer acceptance of graduate competence (Winch, 2020; Rahmaningtyas et al., 2023).

Data were collected from aggregated institutional records, professional competency certification records, prototype documentation, industry internship reports, company supervisor assessments, internal lecturer assessments, and graduate recruitment tracking records. Internship data were obtained from documented student reports and formal assessment records completed during or after the one-year industry placement. These documents were reviewed to identify evidence of competence transfer, including students' ability to follow workplace procedures, revise design outputs, respond to production constraints, coordinate with production personnel, and complete design-related tasks in authentic manufacturing settings. To protect student and industry confidentiality, all data were reported in aggregated and anonymized form. Individual student names, student identification numbers, company names, and detailed placement information were not included in the manuscript. Qualitative evidence from internship documentation was summarized using anonymized codes and paraphrased descriptions.

Data analysis employed a descriptive and explanatory approach to identify consistent relationships between industry-oriented learning processes and externally validated competence outcomes. First, student background data were summarized to identify the proportion of students from design-related and non-design-related high school backgrounds. Second, external competence validation evidence was organized from certification, internship, prototype, and recruitment records. Third, qualitative internship evidence was reviewed to identify recurring examples of workplace competence transfer. Finally, the evidence was interpreted by examining the logical alignment between industry-inspired learning behaviors and externally validated competence outcomes. The analysis emphasized triangulation across multiple evidence sources rather than

statistical testing, which is appropriate for applied vocational education research Creswell and Creswell (2018).

Result and Discussion

The findings are organized around the external and authentic evidence used to validate furniture design competence. Rather than relying only on classroom-based assessment, the study examined whether students could demonstrate competence through professional certification, internship performance, full-scale prototype development, and recruitment recognition. These indicators are important because the main concern of this study is not merely whether students completed learning activities, but whether industry-inspired learning behaviors supported the transfer of campus-based learning into workplace-recognized competence.

Table 2. Summary of external competence validation evidence

<i>Validation indicator</i>	<i>Evidence source</i>	<i>Aggregated result</i>	<i>Interpretation</i>
Establishing furniture design concepts	Certification records of “Merancang Desain Furnitur” scheme	All students participated in the certification scheme and were declared competent/certified	Students’ furniture design competence was externally assessed against recognized occupational standards
Internship performance	Company supervisor and internal lecturer assessment	Aggregated assessment indicated satisfactory workplace performance	Students demonstrated the ability to apply design-related competence during industry placement
Full-scale prototype development	Final project and prototype documentation	Full-scale 1:1 furniture prototype documented as final project evidence	Students translated design documentation into tangible furniture products under production constraints
Recruitment before graduation	Graduate recruitment tracking records	Earlier cohorts before 2021 were all recruited before graduation; 22 of 28 students in the 2021 cohort and 23 of 28 students in the 2022 cohort were recruited before graduation	Employers recognized students’ applied competence and workplace readiness

Professional Certification and Design Feasibility

Professional competency certification provided the first external indicator of furniture design competence. All students participated in the “Merancang Desain Furnitur” certification scheme and were declared competent/certified. The certification process assessed whether students were able

to meet recognized occupational standards related to furniture design, particularly in terms of design feasibility, manufacturability, structural logic, material efficiency, and production readiness. Students were required to prepare design documentation that could be interpreted and used in production, including technical drawings and material specifications.

This finding indicates that industry-inspired learning behaviors supported students in understanding furniture design as an applied vocational competence. SOP-based design stages helped students follow a systematic design process, while constraint-driven tasks encouraged them to consider material availability, construction logic, and production feasibility. Iterative revision cycles further strengthened students' ability to improve design outputs based on feedback. Therefore, certification evidence supports the argument that design competence in vocational education can be developed through structured and industry-aligned learning, rather than depending solely on prior design-related educational preparation (Billett, 2019; Winch, 2020).

Full-Scale Prototype as Competence Integration

In addition to certification, the full-scale 1:1 furniture prototype functioned as authentic evidence of competence integration. Prototype development required students to connect design planning, material selection, construction detailing, and production execution. This process made the relationship between design intent and manufacturing reality visible, because students had to respond to real constraints such as material behavior, structural stability, fabrication process, and assembly logic.



Fig 1: Full-scale 1:1 furniture prototype developed as final project evidence

The prototype evidence strengthens the practical dimension of the study. While certification demonstrates that students could meet formal occupational standards, the prototype shows that students could translate design documentation into a tangible furniture product. This is particularly

important in vocational furniture design education because competence cannot be evaluated only from concept drawings or aesthetic proposals. It must also be demonstrated through feasible, production-ready, and material-efficient outcomes. In this sense, full-scale prototyping became a bridge between classroom learning and manufacturing practice.

Transfer of Design Competence in Industry Internships

The internship phase provided evidence of competence transfer from campus-based learning to workplace settings. During the one-year industry internship, students were placed in furniture manufacturing environments where they were exposed to real production demands, workplace procedures, and coordination with industry personnel. Internship performance was assessed by company supervisors and internal lecturers. The aggregated assessment showed an average internship performance score of 83.02, indicating satisfactory workplace performance.

This result suggests that students were able to apply design-related competence beyond the classroom. Internship documentation and assessment records showed that students were expected to follow workplace procedures, complete assigned tasks, respond to production constraints, and coordinate with relevant personnel. These forms of workplace behavior are closely related to the learning behaviors emphasized in the curriculum, particularly procedural adherence, iterative task engagement, and feedback utilization. Therefore, the internship outcome supports the argument that industry-inspired learning behaviors strengthened students' readiness to operate within authentic furniture manufacturing contexts.

The internship evidence is also important because students came from heterogeneous prior educational backgrounds. For students without prior design-related high school preparation, workplace competence required more than conceptual understanding of design. They needed to internalize how design decisions affect production, material use, construction, and workflow. The satisfactory internship performance therefore indicates that structured, manufacturing-oriented learning helped students develop competence that could be recognized in real industry environments. This adaptive behavior reflects effective learning transfer, consistent with vocational research showing that competence transfer is strengthened when learning activities closely resemble workplace practices Salas et al (2022).

Industry Recognition and Graduate Employability

Graduate recruitment tracking records provided another indicator of externally recognized competence. Recruitment before graduation is significant because it reflects employer confidence in students' readiness to work before they formally complete their study. In this study, recruitment

tracking showed strong employer recognition across cohorts. Students from cohorts before 2021 were all recruited before graduation. For the 2021 cohort, which graduated in 2024, 22 of 28 students, or 78.57%, were recruited before graduation. For the 2022 cohort, which graduated in 2025, 23 of 28 students, or 82.14%, were recruited before graduation.

These findings show that industry stakeholders recognized students' applied competence before formal graduation. From a vocational education perspective, this form of recognition is meaningful because employability is not only an institutional outcome but also an indicator of alignment between learning processes and workplace expectations. The recruitment data therefore support the view that industry-inspired learning behaviors contributed not only to technical skill development but also to broader workplace readiness Winch (2020).

Synthesis of Competence Validation

Across certification, full-scale prototype development, internship performance, and recruitment tracking, a consistent pattern emerges. Students demonstrated the ability to produce feasible furniture design solutions, translate design documentation into tangible products, perform satisfactorily in industry internships, and gain recognition from employers before graduation. These outcomes indicate that competence development was supported by the alignment between structured campus-based learning and authentic industry expectations.

The evidence also reinforces the importance of learning behavior in vocational design education. SOP-based design stages reduced ambiguity for students who did not have prior design-related preparation. Constraint-driven tasks trained students to think within the limits of material, construction, and production processes. Iterative revision cycles encouraged continuous improvement, while feedback from lecturers and industry supervisors helped students refine their design judgment. Together, these behaviors formed an industry-inspired learning pattern that supported the development of furniture design competence. The convergence of these external indicators supports the view that vocational design competence is best understood and validated through applied performance rather than internal academic assessment alone (Billett, 2019; Sudira, 2022).

Implications for Vocational Design Education

The findings suggest that furniture design competence can be developed among students with heterogeneous prior educational backgrounds when learning is structured around industry-inspired behaviors. For vocational institutions, this implies that design learning should not rely only

on studio-based creativity or individual aesthetic ability. Instead, it should integrate procedural guidance, production constraints, feedback cycles, full-scale prototyping, and industry exposure.

This study also shows that competence validation in vocational design education should be based on multiple forms of authentic evidence. Professional certification provides formal occupational validation, prototype development demonstrates tangible production readiness, internship performance shows workplace transfer, and recruitment tracking reflects employer recognition. When these indicators are interpreted together, they provide a stronger basis for evaluating the effectiveness of vocational design learning than classroom assessment alone.

Overall, the findings support the central argument of this study: industry-inspired learning behaviors provide a practical and transferable approach for developing furniture design competence in vocational education. By embedding students in structured, production-oriented learning processes, vocational institutions can help learners without prior design-related high school preparation acquire competence that is not only institutionally assessed, but also externally recognized by industry.

Conclusion

This study examined how industry-inspired learning behaviors facilitate the acquisition of furniture design competence among students without formal design backgrounds in vocational higher education. Using externally validated outcomes professional competency certification, full-scale furniture prototype completion, sustained industry internship performance, and early graduate recruitment the study demonstrates that design competence can be systematically developed when learning processes are deliberately aligned with manufacturing practice.

The findings confirm that furniture design competence is not primarily an aesthetic or conceptual capability, but an applied competence grounded in feasibility, production readiness, and material efficiency. Structured learning behaviors, including SOP-based design stages, constraint-driven tasks, iterative refinement, and 1:1 prototype realization, enabled students to translate design intent into manufacturable solutions. These processes provided novice learners with clear procedural guidance, supporting the internalization of production-oriented design logic.

From a vocational education perspective, the study underscores the importance of coherence between campus-based instruction and workplace expectations. The integration of external professional certification, tangible production outcomes, and extended industry immersion ensured that competence was not only developed within the institution but also validated and accepted by

industry stakeholders. Together, these mechanisms functioned as credible indicators of vocational readiness and labor-market relevance.

In terms of contribution, this study bridges vocational education research and manufacturing-oriented training literature by demonstrating how standardized work practices and applied learning principles can be effectively embedded in furniture design education. The contribution is practical and transferable, offering an empirically grounded learning model that can be adopted by vocational institutions aiming to develop design competence among heterogeneous student populations.

Future research may examine the applicability of industry-inspired learning behaviors across other design-related domains or explore how individual learning components contribute to specific dimensions of design competence. Nevertheless, the present study provides clear evidence that structured, production-oriented learning behaviors constitute a viable and effective approach for preparing non-design-background students for professional roles in the furniture industry.

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